POWER

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The Engineer's Creed

I Believe in my job.

I Believe in my plant and the firm I am working for.

I Believe in myself and my ability to get results.

I Believe in serving my firm honestly and to the best, and respect the confidence and trust placed in me.

I Believe in working, not waiting, in boosting, not knocking, and in the pleasure of performing my daily duties.

I Believe in the purchase of honest materials and equipment, produced upon the standards of honest workmanship, at an honest price, for installation at my plant, whether it be a single valve or a compound generating unit.

I Believe in man and plant efficiency, in the generation of greatest power at lowest cost.

I Believe in keeping accurate records of the daily performances at my plant to serve the best interests of my firm and to further prove my capability as an engineer.

I Believe in adding daily to my store of power-plant knowledge, in keeping fully abreast of the times through the careful reading of current engineering literature, and in thus learning of new ideas, new kinks, new equipment and better methods for the benefit of myself and my firm.

I Believe in safety first, and in such personal care and precaution and the installation of such equipment and devices as make it possible.

I Believe in my fellow men, in giving each man a worthy chance, and in assisting those who are honestly ambitious and seek my aid.

I Believe in progress, in fairness, in courtesy, in kindness, in generosity, in good cheer and good fellowship.

I Believe in my home and that there is no other spot in the world which can fill its place.

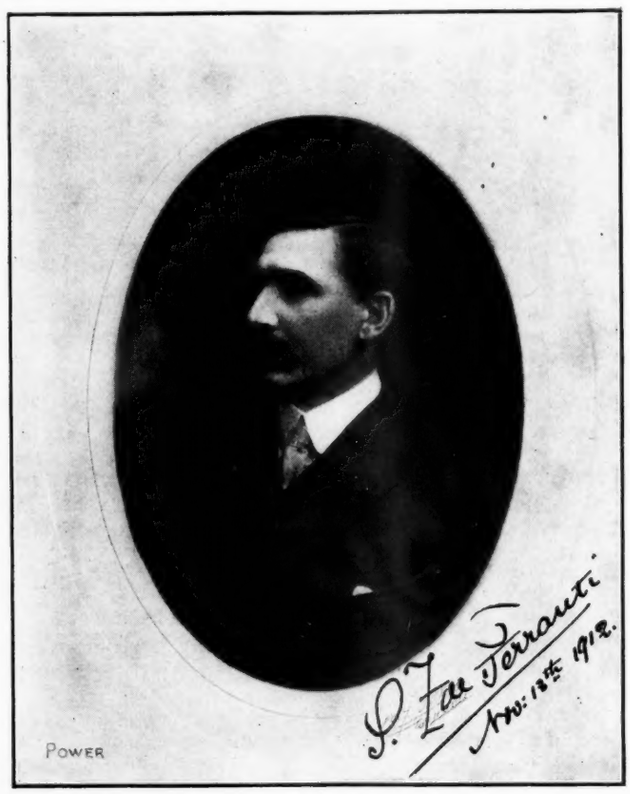
I Believe in to-day and am proud of the work I am doing; in to-morrow and the work I hope to do; and in the future and the reward it holds for me. And believe that no man is down and out until he has lost all faith in himself.

Ferranti and His Turbine

By F. R. Low

SYNOPSIS—An interview with the man who suggested and designed the first station with large direct-connected units, with a description of his new turbine which runs on 9.4 lb. of steam per kilowatt-hour.

In most lines of thought and endeavor there are daring, imaginative pioneers, who foresee the possibilities and blaze a line across the field of coming developments in advance of the traveled road. It is not always they who reap the benefit. Their projects are often so far-sighted and their trail leads so far into the untried, that it is only after years of plodding progress has developed the trail into a commercial highway that the soundness of their judgment and the value of their leadership are assured.



The first time that I ever heard of Sebastian Z. de Ferranti was in connection with the Deptford station, near London. We were still building large electric stations with small units, run from belted countershafts, and thought we had to locate them in the center of distribution to save copper and line losses. Ferranti proposed to meet the London situation with a station situated at Deptford, seven miles from the center of the field of use of the current, and to equip it with units of 7000 kw. capacity, with the engines coupled directly to the generators. His engines were vertical compounds with cylinders 44 and 88 in. in diameter, and the armature of the generator 40 ft. over all. Current was to be generated at 10,000 volts. The units were actually built. I remember the criticism and condemnation which they evoked from conservative electricians and engineers. That they were not installed as intended was due to no fault of the engines or of the general plan, which was carried out upon a smaller scale, but to the fact that the company got only a portion of the concession which it was after, and hence had no need for such large units; but when ten years later the Seventy-sixth Street station was put down in New York, the engines chosen had precisely the same cylinder diameters, and the station carried the same high pressure, 200 lb., that Ferranti had adopted so far ahead of general usage. Quite a number of his engines were built and did good service, but he did not foresee the turbine, which has so much the advantage of them in their particular field, that their manufacture was eventually discontinued.

In January of this year, Ferranti accepted an invitation to deliver the Watt Anniversary Lecture before the Greenock Philosophical Society, in the course of which he announced that he was at work upon a turbine which had already produced remarkable results. Confident that any turbine which Ferranti produced would be full of interest, and anxious to meet a man who had thought so far ahead in the field which POWER seeks to serve, I solicited an interview and received an invitation to visit him at his home in Baslow.

When I alighted from the train at Sheffield, I was prepared to meet a man somewhat along in years, for the Deptford job was done a quarter of a century ago. But the tall, straight, hearty man who came forward with his son to meet me was still on the sunny side of 50, for he was but 24 when he did that audacious job which made his reputation international.

A motor ride of something over a half hour among the Derbyshire hills led us to the Hall, at Baslow, where about a sparkling fire, grateful, although it was in August, the family of my host awaited us.

After dinner we sat about that fire and I asked about the turbine. I wish I could reproduce here the photographs and drawings which the inventor and his two grown-up sons brought out and explained to me. That, I am promised, shall come later, when patents and commercial interests will not be jeopardized. But I am permitted to describe it as well as I can from my notes and memory.

Ferranti's turbine is a superheated steam turbine; so are most turbines, but not so much so as Ferranti's. Superheat is his motive, his theme, his essential feature. His turbine differs from the Parsons mainly in the respect that it is designed and constructed to handle superheat—a higher degree than anybody else uses initially, and then some more, before the steam becomes saturated by expansion, superheat even in the steam as it goes to the condenser.

"Of the heat required to make a pound of steam," says Ferranti, "upward of a thousand units is latent, and most of it will go as latent heat of the exhaust to the condenser. So long as you are going to make this expenditure you may as well make it carry all the useful heat with it that you can. In other words, give it all the superheat that it will carry to start with and reheat it as often and as much as you can. If you could keep this superheat pouring into it so long that the final expansion

would not cool it quite to the point of saturation, so much the better. In practice we cannot do this; we must reheat intermittently, and in the present turbine I have reheated but once."

Let us make this clearer by an example. Assume steam of 150-lb. gage pressure, say, 165 lb. absolute, superheated 400 deg. F., or to a total temperature of 766 deg. F.; to be worked to a vacuum of 28 in., or 1 lb. absolute. To make a pound of such steam from feed water at the temperature corresponding to the lower pressure, 101.83 deg. F., requires 1330.3 B.t.u., of which, if the steam were expanded adiabatically to the lower pressure, 413.53 would be converted into work, and 916.77 voided to the condenser. There would therefore be 31 per cent. of the heat converted to mechanical energy by an engine of 100 per cent. efficiency.

In Fig. 1, where vertical distances represent absolute temperatures, start at *A* with a pound of water as it comes from the hotwell at 101.83 deg., and raise its temperature to 366 deg. F., or 825.6 absolute corresponding to 165 lb. the absolute initial pressure. If the horizontal distances are made such that the area under the curve is proportional to the heat that has been put into the water at any instant, the temperature will rise along the line *AB*, and the area *ABCD* will represent the amount of heat necessary to raise a pound of water from 101.83 to the boiler temperature 366 deg. At *B* the water commences to boil and absorbs heat at the constant temperature 366 deg. F., and the line of constant pressure *BE* is made of such length that the area *BEGC* is proportional to the heat absorbed in evaporating it, the latent heat of the steam tables.

If the application of heat is continued after the water is all evaporated, the temperature of the steam will rise along the line *EH*, and the area *EHIG* is proportional to the amount of heat required to superheat it 400 deg. F. or to 766 deg. F. If, now, it is allowed to expand without receiving or giving up any heat, except that converted into work, its temperature will drop along the line *HI*, and when this temperature has reached the lower limit, 101.83 deg. F., represented by the height of the line *HJ*, an amount of heat proportional to the area *ABEHJA*, will have been converted into work, and the rest, equivalent to the area *AJID* will be rejected to the condenser. In this case, the total heat supplied 1330.3 B.t.u. is represented by the area *ABEHIDA* of which 413.53 B.t.u. represented by the area *ABEHJA*, or 31 per cent., is converted into energy by an engine of 100 per cent. efficiency, working on the Rankine cycle between these limits.

If, now, instead of allowing the steam to cool off, as it expanded, heat were added to it at a rate that would keep its temperature constant up to a point as *K*, and then the steam were allowed to expand adiabatically to *L*, heat proportional to the area *HKLJ* would be added to the convertible portion at the cost of adding heat proportional to *HKMI* to the whole, and it is evident that the area gained is a considerably greater proportion of that added than is the convertible area *ABEHJA* of the previous diagram (*ABEHIDA*). (In fact, to bear the same proportion, the convertible area of the original diagram would have to fill the rectangle *ANHJ*.) To do this would take an amount of heat proportional to the area *HKMI*, or 241.3 B.t.u., making the total heat represented by the diagram *ABEHKMDA* 1571.6 B.t.u., of which that represented by the area above the line *AL* would be convertible. This would be 544.3 B.t.u., or about 34.6 per cent.

This could be done only if heat could be poured into the steam as it was expanding, as by heat communicated through the blades or other inclosing surfaces, and by ceasing this heating when it was desired to change the expansion from the isothermal *HK* to the adiabatic *KL*. This would be impracticable, and Ferranti, not being able to get the whole loaf, goes after half of it. He allows the steam to expand adiabatically on the line *HI* in the diagram, say, to *O*, where it will have a pressure of 29

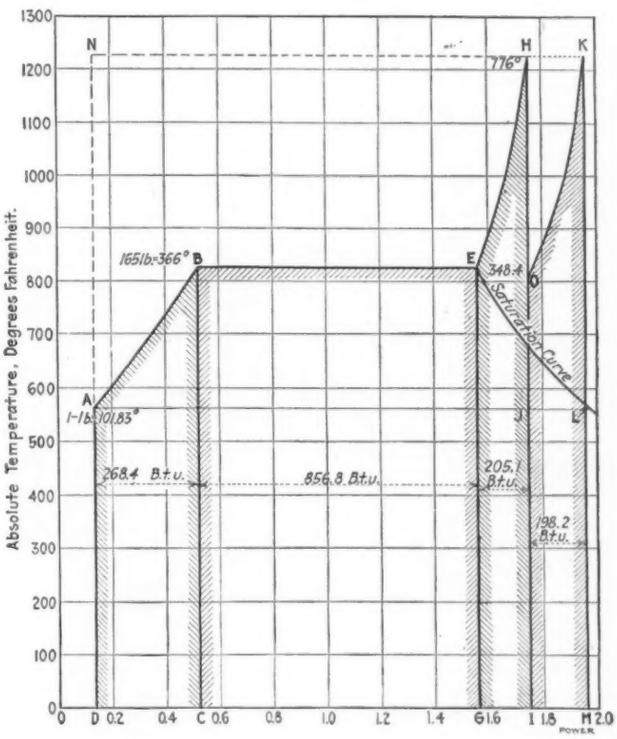


FIG. 1. HEAT RELATIONS IN FERRANTI TURBINE

lb. and 100 deg. of superheat, and be at a temperature of 348.4 deg. F. He then passes it through a reheater, bringing it back to the initial temperature (766 in our assumed case), but at the reduced pressure. The temperature will rise along the line *OK*, and the heat added by the reheater will be proportional to the area *OKMI*, of which that represented by the area *OKLJ* is convertible. The steam then expands adiabatically along the line *KL* to the lower temperature limit. The diagram shows that it would have crossed the saturation curve at this point, but in the actual turbine, due to the taking up of heat from the jacketed casing, the steam is still superheated as it passes to the condenser or to the feed-water heater which precedes it.

The heat required for the final superheating for the supposed condition would be 198.2 B.t.u., making the total heat supplied

	B.t.u.
Heat of the liquid	268.4
Heat of evaporation	856.8
Superheating	205.1
Reheating	198.2
Total	1528.5

Of this 501.2, or 32.8 per cent., is convertible into energy in the two stages. This represents an improvement

in efficiency of 1.72, which is a gain of 5.5 per cent. over that of the former or usual cycle.

If the reheating could be continuous, the efficiency would be still further improved, as has been shown above. The more times the steam could be reheated in passing through the turbine, the nearer this condition would be approached, but loss of pressure head through the reheat-

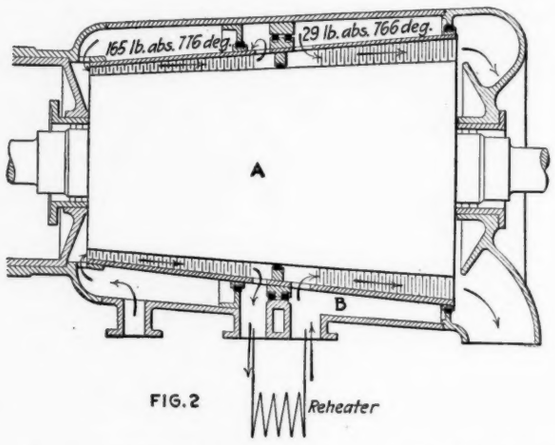


FIG. 2

LONGITUDINAL SECTION OF FERRANTI TURBINE

ers, and other practical considerations would limit the number of times that this could be done with advantage. In the experimental turbine only a single reheating stage is used.

In addition to the theoretical gain in efficiency offered by this cycle it presents the advantage of eliminating moisture from the turbine. As is well known, the first few degrees of superheat improve the actual performance of a turbine considerably more than can be accounted for on a heat-unit basis, presumably because of the elimination of the braking effect of moisture upon the swiftly revolving parts, and of the fact that a considerably less weight of superheated than of saturated steam will leak through a given aperture under a given pressure. The erosive action of the moisture is also avoided when, as in the Ferranti turbine, the steam is superheated throughout its passage.

THE FERRANTI TURBINE

The use of steam of such high temperature involves, however, a turbine especially designed to avoid the stresses and distortion which such temperature ranges involve. Cast iron is totally unadapted for such use, as experience with growing pipe fittings and distorted turbine diaphragms has demonstrated. The Ferranti turbine is therefore made entirely of wrought metal; even the exterior casing is of boiler plate. The movable blades, of the Parsons or reaction type, are carried upon a steel drum not stepped in various diameters as in the usual construction, but of a continuous taper as at *A* in Fig. 2. Surrounding this drum and carrying the stationary blades is another symmetrical cylinder or cone *B* made of boiler steel.

The blades have a tough steel core with a covering of nickel electrically welded on. About the steel blade, already fashioned to the correct section, is wrapped a sheet of nickel some $^1/_{64}$ of an inch in thickness. The whole is heated electrically to a welding heat and rolled while hot through rollers which unite the metals so thoroughly that they do not part even when the blade is twisted, tortured, and bent into any conceivable shape. The coefficient of expansion of the metals is identical, and there is no electrolytic action between them.

At the base of each blade two tiny projections are left, the blade is accurately spotted to its place upon the drum by an automatic machine and current turned on which melts the projections and electrically welds the blade in place, avoiding the distortion and irregular stresses which come from driving and calking blades into a drum cut up by grooves. This method of blading is in successful use not only in the experimental turbine but in the Russian cruiser "Catherine II" and a Turkish cruiser, each of 40,000 hp. The "Kongo," the "Kator," and another vessel now building in Japan, each with 80,000 hp., the highest powered vessels afloat, also have nickel-steel electrically welded blading in the impulse portion of their turbines.

The leading thought in the design is symmetry. No abrupt changes of shape, no irregular members, and the very symmetry that prevents distortion under wide variations of temperature permits closer radial clearances and further reduces the leakage losses. Depending upon this fixity of the relative position of the blades Ferranti equips each row of both rotor and stator with a shroud consisting, as shown in Fig. 3, of a thin strip of metal turned upward and inward at the sides and carrying a strip of graphite which protrudes above the sides of the carrier. The top surface can run very close to the surface of the drum or shell, for contact simply rubs down the graphite and produces automatically a minimum clearance with no danger of fusing or freezing on. The greater diameter made allowable by this close clearance has the advantage of greater peripheral velocity and a greater amount of energy abstracted by each row of blades, therefore a smaller number of stages for a given range of expansion.

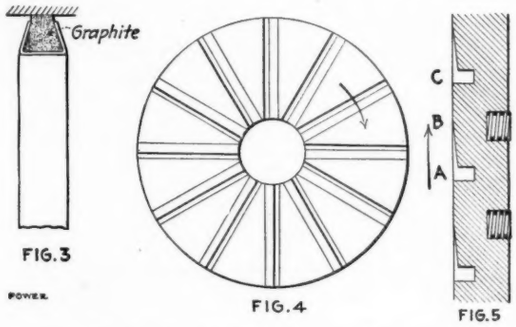


FIG. 3 FIG. 4 FIG. 5

DETAILS OF FERRANTI TURBINE

The number of rows or stages varies inversely as the square of the peripheral speed.

The question will naturally occur, what effect will such a superheat have on the dummy pistons? It would doubtless be very troublesome if there were dummy pistons, but there are none. No attempt is made to balance the end thrust, but it is taken up on a thrust bearing which is a modification of the Kingsbury block. Imagine a disk with radial grooves, as in Fig. 4, a development of the rim of which is shown exaggerated in Fig. 5, the surface from *A* to *B* being inclined at a slight angle to the base, while that from *B* to *C* is parallel. The grooves are filled with oil. A flat disk upon the shaft whose thrust is to be taken, rides upon the surface *BC*, and turning in the di-

rection of the arrow entrains oil up the slight incline, forcing the disks apart. In pockets in the back of the disks, as shown, are springs stressed to some 20 per cent. above the normal pressure. A number of these members are used in series, and as the pressure induced by the entraining action of the disks on the oil increases it compresses the springs, increases the section through which the oil may pass, and distributes the load among the several blocks. The end thrust on the experimental turbine is some 80 tons, and the thrust blocks carry about 500 lb. per sq.in. Ordinary turbine oil is used, circulated and cooled in the usual way.

The cylinder which carries the stationary blading is supported concentrically with the bearing, and quite clear of the necessarily unsymmetrical outside casing. Between the cylinder and the casing are belts for steam of different pressures but of the same temperature. Steam admitted to the first chamber and surrounding the high-pressure end of the shell passes through the first portion of the blading, is drawn off at the point indicated, passed through the reheater, returned to the chamber surrounding the low-pressure part of the shell at the lower pressure, but at the initial temperature. Conduction from this shell, subjected throughout its length to the high initial temperature, tends to keep up the temperature of the steam all the way through the turbine. Packing rings carried on the symmetrical stator drum fit into grooves in the outer casing to separate the pressure chambers while permitting freedom of movement radially and longitudinally.

The experimental turbine has a capacity of 3000 kw. at 1500 r.p.m. It has only two bearings, and is 10 ft. 6 in. between bearing centers. It has produced current at the rate of a kilowatt-hour on 9.4 lb. of steam having an initial pressure of 130 lb., 680 deg. F. total temperature at entry to both high- and low-pressure stages, and with a vacuum of 28.7 in. referred to a 30-in. barometer. It is not possible to state just what efficiency this represents without knowing to what extent the steam was expanded in the first stage, and, therefore, how much heat was added to it in the reheater.

The Venturi Gate Valve

Another invention of Ferranti's which is just becoming known in America is his Venturi valve. Large valves are cumbersome and expensive, and many advantages attend the controlling of the flow of a fluid through a smaller orifice. Ferranti places the gate of his valve in the throat of a Venturi tube, which converts pressure temporarily into velocity, allowing a smaller passage to be used, and restores the pressure upon the "down stream" side. The uniform section of the neck is preserved by a ring drawn into place when the gate is lifted. See POWER, Sept. 24, 1912, p. 475.

A Long Look Ahead

In his inaugural address as president of the Institution of Electrical Engineers, Ferranti gave his imagination full sway in a broad consideration of the subject of coal utilization. If electrical energy could be sold at one-quarter of a cent per kilowatt-hour everybody would use it for all sorts of purposes. Heating would be done and manufacturing processes, such as smelting ore, steel making, etc., carried on by electricity instead of by promiscuous and wasteful coal burning.*

Well, if everybody would use it for such purposes it could be sold at that price, and Ferranti conceives for Great Britain a chain of 100 great central stations, each with 10 generators, turbine-driven, of course, of 25,000 kw. capacity each. The promiscuous demand, of which a large portion would be controllable as to time, would produce a load factor of 60 or more. The coal, instead of straggling over the country in thousands of minute streamlets at infinite cost in labor of handling, would flow in 100 lines in the most efficient manner directly to the 100 points of use, many of which would be contiguous to the mines. Instead of being burned in the present wasteful and inefficient manner, polluting the atmosphere with its smoke and gases, it would be converted in the most efficient way into gas, burned smokelessly as such, and the byproducts recovered, which would furnish fertilizer to enable the land by intensive cultivation to supply the country's food, 77 per cent. of which is now imported. He even hints at controlling the sunshine and the rainfall electrically, remarking that while such speculations may seem only mad visions of the future, they can hardly be considered more improbable than anyone would have considered wireless telegraphy or flight in heavier-than-air machines 50 years ago.

A Boiler-Room School

A school of instruction, for superintendents, engineers and boiler-room foremen, is to be established at the Peoria plant of the Illinois Traction System by Harrington & Peebles, Chicago, advisory engineers on boiler-room economy. The plan is to equip one boiler with a full set of both indicating and recording instruments to show and record draft and temperature changes that take place with different conditions and methods of firing. Both the coal and water will be continuously measured and a test may be conducted at a moment's notice.

It is intended to indicate to the engineers and firemen the value of different parts of the boiler, the most efficient methods of firing, the use of the various instruments necessary in detecting efficiency losses and the value of smokeless combustion, the effect on efficiency of soot and scale accumulations, the effect of various sizes and kinds of coal and the most efficient percentage of CO_2.

Not only will this be demonstrated on the test boiler, but when a condition of highest efficiency is obtained, it will immediately be applied to the rest of the plant and a practical demonstration made of the possibility of applying such a condition to any entire plant.

Mr. Chubbuck, vice-president of the Illinois Traction System, has shown progressiveness in thus establishing the first school of its kind in street-railway power plants.

Mr. Harrington was for many years the chief engineer of the Green Engineering Co., Chicago, and Mr. Peebles was his assistant in the engineering department of the same company.

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*Since writing the above a friend has called my attention to an acknowledgment in Rodenhauser's work on "Electric Furnaces in the Iron and Steel Industry," that Ferranti was first to recognize that by the use of the induction furnace we are able to obtain any desired current strength in the secondary circuit by properly winding the primary, and to use the idea in the design of an electric furnace, described in his patent in 1887. How many people were thinking about electric furnaces upon a large scale at that time?

Air-Compressor Installation and Operation

By E. M. Ivens

SYNOPSIS—The compressor is not the rough and ready machine imagined by some engineers. For efficient service and safe operation, it must be properly installed and given faithful attention. How to do this is simply told in the following article.

Unsatisfactory operation of air compressors and disastrous explosions in receivers and pipe lines emanate mostly from improper installation in the first place and continued negligent operation and disregard of the compressor manufacturer's instructions in the second place. Unfortunately, many operating engineers look upon the compressor as a rough and ready machine built to withstand all manner of abuse, expensive to operate, and only to be used when nothing else will serve the purpose. This impression is erroneous and is easily corrected if the intended operator, before erecting a compressor, will familiarize himself with the practical principles of air compression; the attendant dangers and necessary precautions; and the simple requirements essential to economical operation. A few instructions follow which if observed only indifferently will furnish the much needed relief to the compressor, as well as reduce operating costs and eliminate the danger of the now too frequent explosions.

Location

In installing a new compressor, the first consideration is where to build the foundation. The cleanest and coolest place available in the room should be chosen, and ample space provided all around so that cleaning and inspection of the compressor may be easily accomplished. Location in boiler rooms and near coal piles, which is so often done, should be especially avoided.

Foundation

To appreciate the value of a good foundation, consider the exacting and severe duty that the compressor is required to perform. The earliest type of dry compressor and the one in most general use at present is the straight-line steam-actuated machine. The principle is simply the direct application of power to resistance by the use of tandem pistons and extended rod.

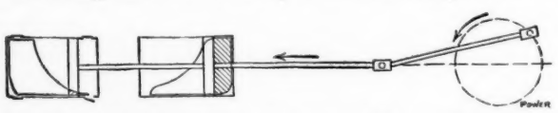


Fig. 1. Diagrams from Straight-Line Compressor; Power Maximum, Compression Minimum

Referring to Figs. 1 and 2, the pressure relations are as follows: During the first part of the stroke the energy in the steam cylinder is at its greatest, while in the air cylinder compression is just beginning, and consequently the resistance is least. As the pistons advance, the steam and air pressures approach a balance until at some point past mid-stroke power and resistance are exactly equal. After this neutral point is past, the ratio of power to resistance then decreases until finally at the end of the stroke, the former is minimum, and the latter is maximum. The excess of power in the steam cylinder at the beginning of the stroke is stored up in the flywheels, increasing their momentum, and is returned to the shaft during the latter part of the stroke, helping the machine over each dead center.

The duplex type of compressor is, in effect, two straight-line compressors placed side by side, and connected by a common crankshaft on which is mounted the balance wheel. The crank of one side is set a quarter of a circle in advance of that of the other side so that when the pistons of one are at mid-stroke those of the other side are at the beginning or end of their stroke. Fig. 3 shows

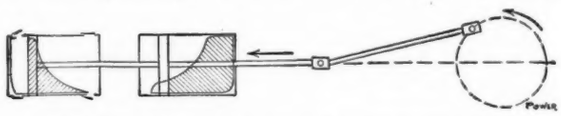


Fig. 2. Power Minimum and Compression Maximum

the steam pressures and opposed air pressures at the beginning of a revolution. Power is in excess of resistance in the upper set of cylinders, while in the lower cylinders the reverse exists. The surplus power in the upper steam cylinders is applied through the crankshaft to carry the lower half over the center.

Fig. 4 shows the instantaneous steam and air pressures a quarter of a revolution later. Here, power is in excess of resistance in the lower cylinders, and minimum power is opposed to maximum resistance in the upper cylinders. Assistance is now received by the upper half from the lower half by the transmission of the surplus power through the crankshaft as before.

A quarter of a revolution later, Fig. 5, the compressor has begun its return stroke, and the conditions are exactly the same as those shown in Fig. 3, but reverse in direction. Fig. 6 shows the conditions existing during the last part of the revolution which are identical with those shown in Fig. 4, but also reverse in direction.

Thus it can be readily seen that aside from the vibrations characteristic of all reciprocating machinery, the compressor is subjected to unbalanced shocks, and strains that are imposed by the nature of the duty and which also must be absorbed by the foundation. The size and depth of foundation depends largely upon the nature of the soil in which it is to be built. The manufacturers send out detailed foundation plans with each compressor, assuming, of course, that the foundation is to be built in reasonably firm ground, but if the ground is insecure, a liberal base a foot or more larger all around than the foundation bottom should be added to the manufacturer's specifications. It is important that special pains be taken to make the foundations for straight-line compressors of liberal size and rigidity, and it is a good plan to reinforce concrete foundations with ½- or ⅝-in. iron rods near the top and bottom, placing some lengthwise and others crosswise of the foundation. In the duplex type of compressor, the unbalanced strains are considerably less, but the same care should be taken in building the foundation.

Receiver

The functions of the air receiver are to create a cushion and thereby eliminate the pulsations in the pipe line, to

serve as a storage of power, to cool the air and precipitate any oil or moisture carried in entrainment, and to eliminate certain friction losses that would occur if cooling were effected in the pipe lines. The receiver should consequently be located in a cool place, preferably outside of the building, and as close as possible to the compressor. Receiver fittings should include a pressure gage, safety valve and blowoff cock located at or near the bottom.

Air-Inlet Piping

An increase of 5 deg. F. in temperature of the intake air is accompanied by a decrease of 1 per cent. in volumetric efficiency. This means that as intake-air temperature increases, the free air capacity of the machine decreases, and the same amount of energy is expended as though the full capacity of the machine were being realized. To assist the compressor, then, the inlet should be piped to the outside of the building, and up some 10 or 12 ft. above the ground surface. The opening should be well screened to prevent drawing in dust and dirt and hooded to keep out rain. If it is impracticable to carry the intake outside and air must be drawn into the cylinder directly from the room, it is very important that no dust or dirt be allowed near the opening, for a small amount being continually drawn into the cylinder with the air will cut and wear the inner surfaces and valves very rapidly, and no end of trouble results.

Sometimes conduits are used instead of piping to the inlet. These are best constructed of wood lined with tin and the opening well screened. Concrete or brick construction should be avoided, for grit is liable to be loosened by the vibrations of the compressor and drawn into the cylinder. Conduits should be of at least double the cross-sectional area of the inlet opening of the compressor.

As few bends as possible should be put in inlet piping, and when used, should be either long-turn fittings or pipe neatly bent, preferably the latter. To further reduce frictional resistance the inlet piping should be increased in diameter in proportion to its length. A good rule to follow is to increase the diameter ½ in. for each 10 ft. added in length.

Discharge Piping

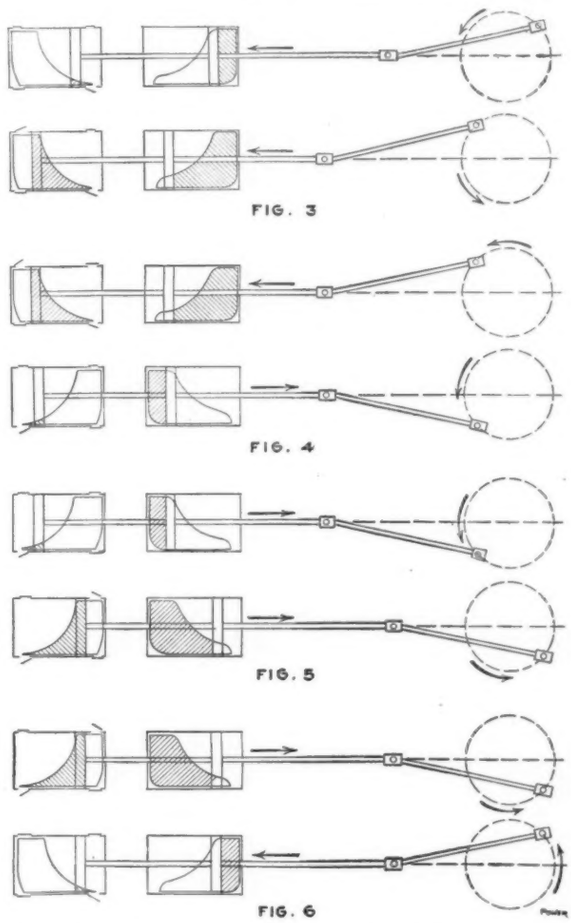
The pipe connecting the compressor and receiver should be of at least the diameter of the discharge opening of the cylinder and contain as few bends as possible. Very often, a salesman in taking an order for an air receiver, recommends one whose inlet opening is considerably smaller than the compressor-discharge opening. When the receiver arrives, and the engineer on the ground learns this, he immediately proceeds to insert a pyramid of bushings in the cylinder opening. This imposes additional hardship on the compressor and creates a condition conducive to an explosion.

Another serious mistake that is often made is the placing of a stop valve between the compressor and receiver. This should never be done unless a safety valve is placed between the stop valve and the air cylinder, for there is a possibility of at some time starting up with the stop valve closed when a dangerous pressure will soon be reached and an explosion is likely to occur.

Lubrication

The bearings and other external wearing parts of the air compressor are usually lubricated either by means of oil and grease cups suitably placed, or by a splash or bath system. The latter method is coming into more popular favor and is rapidly replacing the former because of its simplicity, effectiveness and economy in the use of oil. Against it stands the objection that it is likely to be neglected and the oil allowed to become dirty and gritty, due to accumulation of abrasives gathered by the oil in passing and repassing over the bearings.

Air-cylinder lubrication is by far the most vital point in air-compressor operation, and it seems to be the least understood. In order to fully appreciate the necessity of proper cylinder lubrication, consider the conditions that have to be met. The compression of a gas is accompanied



Duplex Compressor Diagrams, Showing Relative Relations between Power and Compression

by a rise in temperature in accordance with the well known law of thermodynamics. The temperature of the air at discharge from the cylinder is dependent upon not only the pressure but upon the temperature of the intake air as well. Assume that a single-stage compressor is operating at sea level, that the atmospheric temperature is 60 deg. F. and the discharge pressure is 70 lb., the final temperature of the air will be 866 deg. abs. or 406 deg. by the thermometer. This calculation is based on no heat radiation losses and is consequently slightly greater than the actual discharge temperature. The difference between actual discharge temperature and that calculated above is small, for the actual compression line follows the adiabatic very closely. Air is one of the poorest conductors of heat and the water jacket has little effect other than facilitating lubrication. Tests of compressors operating under conditions named show that the actual

discharge air temperatures range between 325 and 365 deg. F. and instances of even higher are on record.

The lowest temperature at which an oil will give off combustible vapors is called the flash point and the temperature at which these vapors ignite and continue to burn, is the ignition point. The flash point of common lubricating oil is about 260 deg. F., and the ignition point about 295 deg. Common cylinder oils flash at about 350 deg. and ignite at about 400 deg. F. The oil best suitable to air-cylinder service is one having a flash point of about 500 deg. and an ignition point of about 600 deg. F.

If proper oil is used, a comparison of temperatures will show that under ordinary conditions and with cylinder and valves in good condition, an explosion is impossible. If, on the other hand, a low-flash-test cylinder oil is used, it is soon decomposed by the heat and the volatile constituents are ignited and a destructive explosion usually follows. There are instances on record where ignition has occurred without explosion, but the chances are always in favor of explosion.

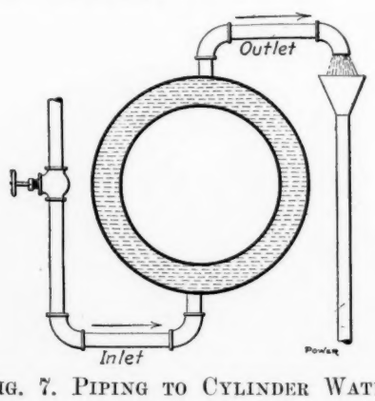


FIG. 7. PIPING TO CYLINDER WATER JACKET

A scored cylinder and valves caused by dirt and grit drawn in with the air and sticking discharge valves may also cause the ignition of volatile constituents of the oil. For instance, suppose that a sufficient amount of air at discharge temperature found its way back from the receiver or pipe line into the cylinder on the suction side of the piston, to raise the initial temperature from 60 to 200 deg. F. This air might return either through leaky or sticking discharge valves, or from the compressing side of the moving piston to the suction side. Then with 200 deg. F. initial temperature, the final temperature of air compressed to 70 lb. gage would be 635 deg. F., which is high enough to decompose and ignite even the best of oils. This shows the importance of locating the compressor so that the coolest and cleanest air obtainable is drawn into the cylinder. Other conditions which are favorable to ignition are carbon deposits from the oil on the valves and passages restricting their area; too small a discharge pipe; and drawing air from a hot engine room. Any of these cause at least an increased final temperature, and each, if extreme, will ultimately cause ignition.

Only a very small amount of oil is necessary for the air cylinder and as little as possible should be used, for excess of oil will deposit carbon and gum the valves. Just how much can best be determined by experiment, but a good approximation is one drop per minute for cylinders of from 6- to 10-in. stroke, three drops in two minutes for cylinders of from 12- to 16-in. stroke, two drops per minute in cylinders of from 18- to 24-in. stroke, and three to five drops for larger cylinders. These quantities apply when the compressor is running at normal speed, and if for any reason the revolutions are increased or decreased, the quantity of oil should also be varied in proportion.

CIRCULATING WATER

The duty of the jacket water is to carry off the heat transmitted to the cylinder walls and heads by the compression of the air, and thereby assist lubrication. A liberal supply of cool water should be furnished the jacket and necessary precautions taken that will prevent starting up with a dry jacket. Air cylinders are provided with water-inlet and outlet openings as well as a drain. In some cylinders, inlet and outlet openings are at the top of the barrel while in others, the inlet is below and the outlet above the barrel. In the first instance, there can be no mistake in making pipe connections, but with the latter arrangement of openings, the error is often made of connecting the inlet pipe above into the outlet opening. When this error is made, the jacket is not kept full of water, and the surfaces not in contact with the water will become heated.

The water outlet should be in plain view of the operator and this is best accomplished by allowing the water to fall into an open-pipe end or funnel, as shown in Fig. 7. The controlling valve should always be placed in the inlet. Sometimes the circulating water is used for other purposes after leaving the jacket, and a closed circuit is necessary. The jacket-water pressure should not exceed 50 to 60 lb. unless special attention has been given to the design. Dirty circulating water is injurious in that mud deposits will form which prevent the water from reaching the metal and heating will result. If the compressor is exposed to freezing temperature, the jacket should be drained after shutdown; otherwise the expansion of the water in freezing will crack the jacket.

INSPECTION AND CLEANING

At stated intervals, say, every month, the compressor should be thoroughly inspected and any defect corrected immediately. The air valves of the modern compressor are usually placed conveniently and can be easily removed and examined. They should present an oily surface and be kept free of carbonaceous deposits. The ports and passages should also be kept clean and free from obstructions.

Cleaning of the inside of the air cylinder may be done effectively by filling the lubricator with a strong solution of water and soap, and feeding liberally throughout a day's run. Liberal quantities are necessary because soap in itself is not a very good lubricant. At the end of the day's run the lubricator should be filled with oil and the compressor operated for awhile. This to prevent rusting of the inner polished surfaces. Because of its low flash point, kerosene should never be used for cleaning the cylinder.

Summing up all that has been said, the following mode of operation is obviously to be recommended:

Every morning—Drain the receiver; notice the height of lubricating oil in the crank case or in the oil cups and replenish if necessary; adjust the lubricator for the proper amount of oil feed; start the circulating water.

Every week—Remove the crank-case oil and filter it;

remove and examine the suction and discharge valves, if worn or cut, they should be ground to a tight fit; test the safety valve by raising the air pressure to the point of blowoff; take up lost motion in the pins and bearings.

Every month—Renew the crank-case oil and thoroughly cleanse the inside of the crank case; thoroughly inspect all parts, including the air and water passages.

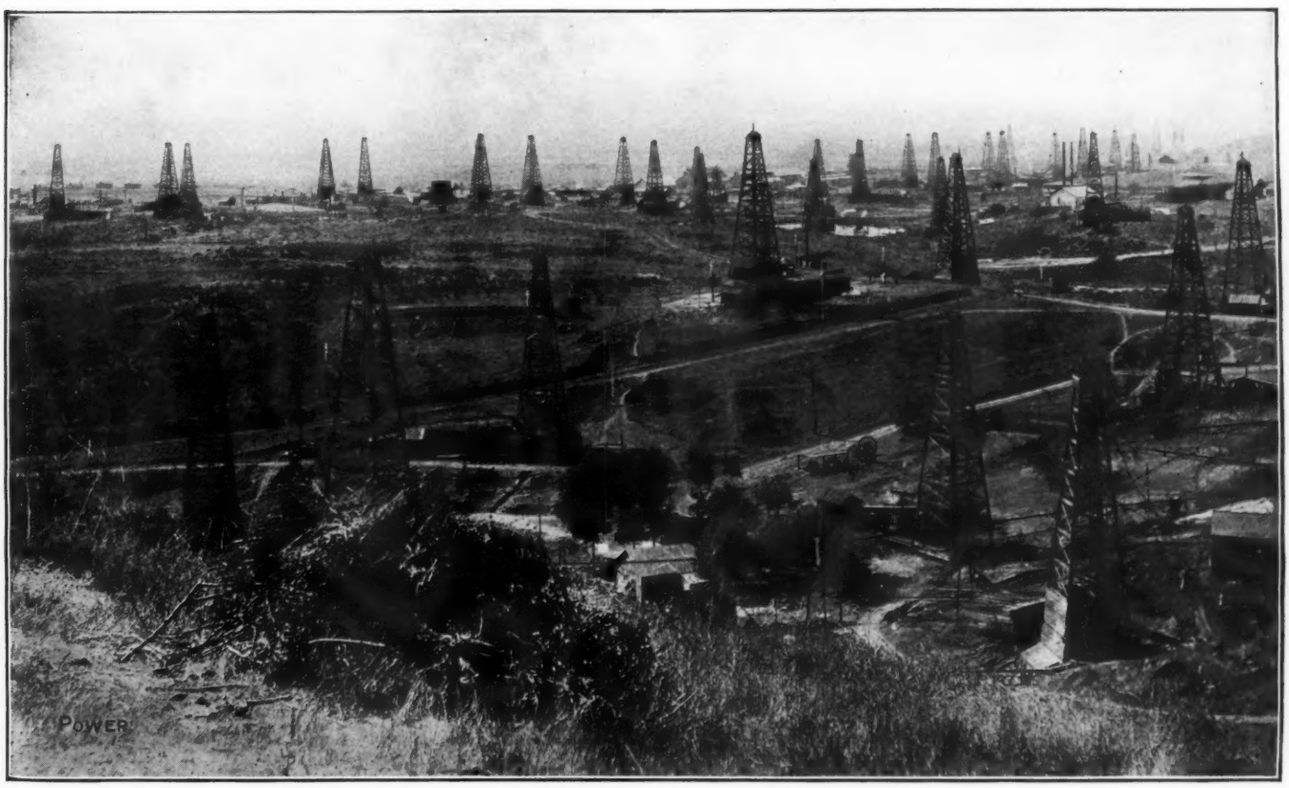
Like any other piece of machinery, the air compressor will need thorough overhauling at some time. The parts most likely to break are the valves and it is advisable to carry on hand a complete set of both inlet and discharge valves for emergency and thus avoid expensive shutdowns while waiting for new ones from the factory, or else operating with a badly worn or broken valve.

The World's Fuel-Oil Production

By J. J. McIntosh

SYNOPSIS—Uses of fuel oil and comparative productive records of different countries.

A review of the progress of petroleum development shows that in the early stages of this industry, discoveries of oil deposits were, in a large measure, controlled by chance. In some oil fields the discovery followed the investigation of seepages, while in others the presence of oil was discovered while drilling for water or the presence of gas led to investigation. Owing to the vastly superior knowledge, in the matter of oil-bearing formations, which we now possess, the element of chance is eliminated and we are able to systematically trace oil-bearing strata under large areas. The enterprise and diligence of the United States Geological Survey in its work of investigating local geological conditions has been chiefly instrumental in bringing this about.



Oil Fields of Southern California

The use of oil fuel on the railroads and in the United States navy and merchant marine service is rapidly increasing. The transcontinental railroads are now using oil fuel on many miles of line. Some of the railroads in the northwestern part of the United States and in southern Canada held to coal for a considerable period after the permanency of the fuel-oil supply was assured. The last tie to coal became broken with the realization that the failure of their immense locomotives to move the weight that had been confidentially expected of them, was not the fault of the machines. The weight of trains over the mountain divisions was invariably limited to the endurance of the fireman. Shoveling coal on the large engines over these divisions is a task that few can stand up to. With the use of oil as fuel this feature was entirely removed.

The United States navy has some 20 oil-burning torpedo-boat destroyers, and eight battleships which burn oil as auxiliary to coal. The battleships "Nevada" and "Oklahoma" burn oil exclusively.

An event of interest in the merchant marine service was the voyage of the "Honolulan" from Baltimore, Md., to Seattle, Wash. This vessel carried a cargo of 7000 tons of coal but was propelled by oil. The journey covered 14,000 miles and required a barrel (42 gal.) of oil per

mile. The oil weighed 1866 short tons, and to serve the same purpose it is estimated that 5600 tons of coal would have been needed.

Production Data

A glance at Table 1 shows the world's total production in 1911 to be 345,512,185 bbl., or over 46,500,000 metric tons. The United States ranks first in the production of petroleum, producing 63.8 per cent. of the world's total output. Table 2 gives the total quantity and value of petroleum produced in the United States and the average price per barrel in 1910 and 1911, by states, in barrels. Table 3 gives the percentage of increase or decrease, of the different states in 1910 as compared with 1911. California ranks first with a production of 81,134,391 bbl. in 1911 to her credit. Oklahoma ranks second with a production of 56,069,637. In 1912 the production of petroleum in Oklahoma declined to about 52,000,000 bbl. while the California output for the same year increased to about 87,000,000 bbl. Referring to Table 3, the total increase in the United States in 1911 over that of 1910 is 5.20 per cent. Table 4, giving the well record in the United States for 1911 is of interest. Tables 1 to 4 inclusive, were compiled by the United States Geological Survey.

In regards to the oil production in Mexico, the United States Geological Survey reports as follows: "The quantity of oil which the Mexico fields are now ready to furnish is variously estimated at from 6,000,000 to 12,000,000 bbl. a month. The total production was perhaps a tenth as much, the production being limited neither by supply or demand, but by transportation facilities. The needed tank steamers are being furnished as rapidly as they can be built. It should be borne in mind, however, that, given a supply of tank steamers sufficient for all the oil that can now be furnished for the Eastern coast, the market would probably be temporarily oversupplied. The consumers of fuel require time for the substitution of oil for coal, though the many advantages of the former are obvious."

Another factor in the future production of petroleum that is worthy of consideration will be the opening of the Panama Canal. This, in all probability, will be the means of opening up oil lands in Mexico and South America.

TABLE 1. WORLD'S PRODUCTION OF CRUDE PETROLEUM, 1906-1911, BY COUNTRIES, IN BARRELS AND METRIC TONS

Country	1907	1908	1909	1910	1911 Rank	1911 Barrels	1911 Metric Tons	1911 Per Cent. of Total Production
United States	166,095,335	178,527,355	183,170,874	209,557,248	1	220,449,391	29,393,252	63.80
Russia	61,850,734	62,186,447	65,970,350	70,336,574	2	66,183,691	9,066,259	19.16
Mexico	1,000,000	3,481,410	2,488,742	3,332,807	3	14,051,643	1,873,552	4.07
Dutch East Indies	9,982,597	10,283,357	11,041,852	11,030,620	4	12,172,949	1,670,668	3.52
Roumania	8,118,207	8,252,157	9,327,278	9,723,806	5	11,101,878	1,544,072	3.21
Galicia	8,455,841	12,612,295	14,932,799	12,673,688	6	10,485,726	1,458,275	3.04
India	4,344,162	5,047,038	6,676,517	6,137,990	7	6,451,203	897,184	1.87
Japan	2,010,639	2,070,145	1,889,563	1,930,661	8	1,658,903	221,187	0.48
Peru	756,226	1,011,180	1,316,118	1,330,105	9	1,398,036	186,405	0.40
Germany	756,631	1,009,278	1,018,837	1,032,522	10	995,764	140,000	0.29
Canada	788,872	527,987	420,755	315,895	11	291,096	38,813	0.08
Italy	59,875	50,966	42,388	42,388	12	*a*71,905	10,000	0.02
Other	*a*30,000	*a*30,000	*a*30,000	*a*30,000	..	*a*200,000	26,667	0.06
Total	264,249,119	285,089,615	298,326,073	327,474,304	..	345,512,185	46,526,334	100.00

a Estimated.

TABLE 2. TOTAL QUANTITY AND VALUE OF PETROLEUM PRODUCED IN THE UNITED STATES AND THE AVERAGE PRICE PER BARREL IN 1910 AND 1911, BY STATES, IN BARRELS

State	1910 Quantity	1910 Value	1910 Average Price per Barrel	1911 Quantity	1911 Value	1911 Average Price per Barrel
California	73,010,560	$35,749,473	$0.490	81,134,391	$38,719,080	$0.477
Colorado	239,794	243,402	1.015	226,926	228,104	1.005
Illinois	33,143,362	19,669,383	0.593	31,317,038	19,734,339	0.630
Indiana	2,159,725	1,568,475	0.726	1,695,289	1,228,835	0.740
Kansas	1,128,668	444,763	0.394	1,278,819	608,756	0.476
Kentucky	468,774	324,684	0.693	472,458	328,614	0.696
Louisiana	6,841,395	3,574,069	0.522	10,720,420	5,668,814	0.529
Michigan, Missouri	3,615	4,794	1.326	7,995	7,995	1.000
New York	1,053,838	1,414,668	1.342	952,515	1,248,950	1.311
Ohio	9,916,370	10,651,568	1.074	8,817,112	9,479,542	1.075
Oklahoma	52,028,718	19,922,660	0.383	56,069,637	26,451,767	0.472
Pennsylvania	8,794,662	11,908,914	1.354	8,248,158	10,894,074	1.321
Texas	8,899,266	6,605,755	0.742	9,526,474	6,554,552	0.688
Utah, Wyoming	115,430	93,536	0.810	186,695	124,037	0.664
West Virginia	11,753,071	15,723,544	1.338	9,795,464	12,767,293	1.303
Total	209,557,248	$127,899,688	$0.610	220,449,391	$134,044,752	$0.608

TABLE 3. TOTAL PRODUCTION OF PETROLEUM AND PERCENTAGE OF INCREASE OR DECREASE BY STATES, IN 1911, AS COMPARED WITH 1910, IN BARRELS

State	Production 1910	Production 1911	Increase	Decrease	Percentage Increase	Percentage Decrease
California	73,010,560	81,134,391	8,123,831	.....	11.13	.....
Colorado	239,794	226,926	.....	12,868	.....	5.37
Illinois	33,143,362	31,317,038	.....	1,826,324	.....	5.51
Indiana	2,159,725	1,695,289	.....	464,436	.....	21.50
Kansas	1,128,668	1,278,819	150,151	.....	13.30	.....
Kentucky	468,774	472,458	3,684	.....	0.0078	.....
Louisiana	6,841,395	10,720,420	3,879,025	.....	56.70	.....
Michigan, Missouri	3,615	7,995	4,380	.....	121.2	.....
New York	1,053,838	952,515	.....	101,323	.....	9.61
Ohio	9,916,370	8,817,112	.....	1,099,258	.....	10.98
Oklahoma	52,028,718	56,069,637	4,040,919	.....	7.77	.....
Pennsylvania	8,794,662	8,248,158	.....	546,504	.....	6.21
Texas	8,899,266	9,526,474	627,208	.....	7.05	.....
Utah, Wyoming	115,430	186,695	71,265	.....	61.74	.....
West Virginia	11,753,071	9,795,464	.....	1,957,607	.....	16.66
Total	209,557,248	220,449,391	10,892,143	.....	5.20	.....

TABLE 4. NUMBER OF WELLS AND DAILY PRODUCTION

Field	Wells Completed Oil	Gas	Dry	Total	Initial Daily Production, in Barrels Total	Average per Well
Appalachian	2978	976	1060	5,014	28,100	9.44
Pennsylvania and New York	1491	219	297	2,007	4,912	3.29
Central and southeastern Ohio	765	403	512	1,680	10,923	14.28
West Virginia	622	351	218	1,191	10,443	16.79
Kentucky	100	3	33	136	1,822	18.22
Lima-Indiana	554	23	67	644	7,477	13.50
Lima, Ohio	480	15	32	527	6,381	13.29
Indiana	74	8	35	117	1,096	14.81
Illinois	1061	41	263	1,365	66,851	63.01
Mid-Continent	3796	490	686	4,972	453,907	119.58
Kansas	172	150	96	418	3,271	19.01
Oklahoma	3294	304	489	4,087	262,333	79.64
Northern Texas	84	4	38	126	19,180	228.33
Caddo[a]	246	32	63	341	169,123	687.49
Gulf	415	50	149	614	106,885	257.55
Costal Texas	352	33	117	502	32,740	93.01
Costal Louisiana	63	17	32	112	74,145	1,176.90
California	963	.....	104	1,067	.....	.....
Colorado	14	.....	18	32	.....	.....
Wyoming and Utah	37	.....	16	53	.....	.....
Total	9818	1580	2363	13,761	.....	.....

a Includes Marion County, Tex.

and thus a supply of oil will be made available for replacing coal to a considerable extent along the Atlantic seaboard, and in some of the Eastern states.

Out of the total production of petroleum in the United States for 1912, about 75,000,000 bbl. was used for fuel. Of this amount, probably two-thirds used was the crude oil, while the remaining was in the form of residues after the light distillates were taken off. The residues from the petroleum found in the Eastern fields is not used as fuel, it being valuable for manufacture into lubricants, paraffin wax, etc.

Although this amount is only a little over one-third of the total production in the United States, it must be remembered that a considerable portion of the amount produced went into stocks. In California alone the stocks amount to approximately 45,000,000 bbl. From this it is evident that a considerable portion of the oil produced was used as fuel.

❖ ❖

Some Troubles of High-Speed Belt Drives

By James A. Seager

SYNOPSIS—By carrying a motor on a spring support above the floor the jerky action of a high-speed drive is eliminated. A simple arrangement of two idler pulleys on an adjustable link-frame support enables the belt to make the required arc of contact even at very high speeds.

❖

A motor can often be applied in a position where a piece of line shafting cannot be conveniently located, but there are times when a motor-drive installation plan requires considerable thought to get best results. It may, therefore, be interesting to refer to one such instance in connection with the motor-drive scheme in a cabinet maker's shop and sawmill.

The excellent plan of placing the machinery itself on a false floor elevated some 4 or 5 ft. above the ground floor of the building was adopted, so as to place the electric motors underneath the working floor of the factory and also to provide accommodation for a system of shaving and dust removal. The advantage of this system of installation is obvious, as both head room and floor room are saved by putting the motors below the machines and having nothing but a short length of belt coming into the working room.

In connection with one of the machines, however, a large four-cutter molding machine, some difficulty was experienced in getting satisfactory operation, owing to the arrangement shown in Fig. 1 being adopted. Owing to the short length of the belt, the high speed at which it traveled and its vertical position it was extremely difficult to keep it from slipping as it stretched. Much trouble, therefore, was occasioned by taking up the belt from time to time and finally the arrangement shown in Fig. 2 was devised.

The ends of two pieces of bar iron A of flat section were heated and while red hot, bent over a round bar so as to form an eye B. The bars were then bent into the position shown and a 1-in. hole drilled at C. The two bars pivoted at B were then placed under the base plate of the motor so as to lie centrally with the bolt holes in the base and corresponding holes were drilled in the bars, the base being then bolted up to the bars so as to tightly secure them.

Four angle pieces D to support the bars were fixed to the floor. A bar was also passed through the angle irons at the right, and upon this bar were placed two threaded bolts, each ¾ in. in diameter and having at the lower end an eye which slipped over the bar just mentioned. These bolts were fitted with nuts and washers and a spiral spring capable of resisting strong compression.

The motor was thus hung on two spiral springs, the weight of the motor being balanced by the compression on the springs. By tightening or slackening the lower nuts the springs could be compressed or extended so as to give the weight of the motor more effect and thus raise or lower it in position. After the belt was put on, the lower bolts were slackened until a sufficient tension was given to the belt. The elastic nature of the suspension frame provided against the sudden jerks which inevitably occur in a molding machine when the work is put into the cutters, and for this reason the arrangement may be recom-

mended to any factory engineer who finds trouble owing to short, jerky drives.

Difficulty has often been experienced in arranging and running and electric motor drive for high-speed woodworking tools, owing to both the motor and the machine spindles running at high speed. With small pulleys there is usually much slipping when running at high speeds. Sometimes, after the proper size of pulley and the proper width of belt has been used to transmit a given power, the belt, for some reason, slips badly, and the power cannot be obtained. The reason for this is twofold. In the first place, with high belt velocities there is a tendency for the belt to carry with it on its under surface, between the belt and the pulley, a thin layer of air which de-

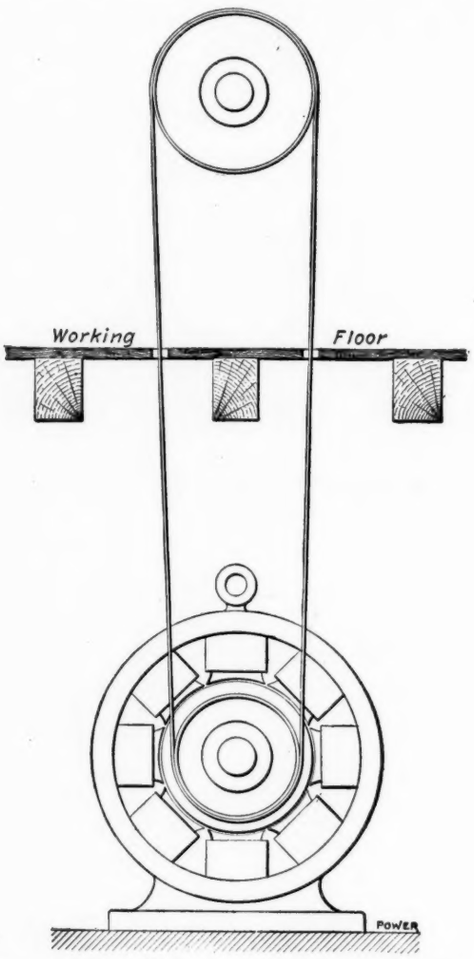


FIG. 1. MOTOR DRIVE FROM BELOW FLOOR

stroys the adhesion and hence prevents the transmission of power. So serious is this evil that in many cases it has become advisable to drill holes in the faces of the pulleys fairly close together to provide air vents so that air carried under by the belt can be squeezed out. This expedient will often increase the power transmitted at high speeds.

There is another trouble with high-speed transmissions, however, that cannot be so easily overcome. This is owing to the centrifugal force of the belt which exerts a stretching action and tends to make it run in a straight line instead of around the pulley. This action, exaggerated, is shown in Fig. 3. The result of this is that while the belt is at rest there is sufficient arc of contact on the pulley surface, but when the belt is in action this arc tends to diminish, until at very high speeds it decreases so much that there is loss of power.

A good arrangement to overcome this difficulty is shown in Fig. 4. Just above the lower pulley and on each side of it are two idler pulleys on pivoted arms held by a frame or supported on the floor so that the arms are parallel to one another. The two free ends of the pivoted arms *A* are held together by two eye-bolts *B* with right and left threads respectively, the eyes being slipped over projections on the pivoted rods. The screwed ends of these eye-bolts are connected by a right- and left-handed muff coupling, so that by turning the coupling the idler pulleys may be drawn in toward each other or allowed to move outwards.

When the belt is in position it bears on both pulleys and will move them, owing to the flexible nature of the arrangement, so that the bearing pressure of each pulley on the belt is equal to that on the other and this condition will maintain itself whether the belt is running or at a standstill; i.e., the belt will be controlled by the position of the idler pulleys. The bending tendency due to centrifugal force, shown in Fig. 3, only occurs

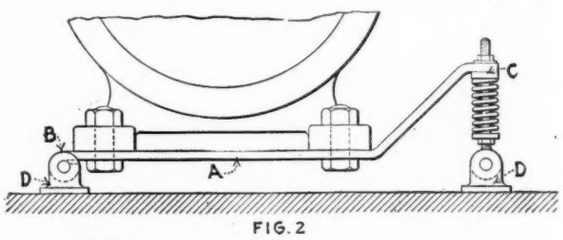


FIG. 2

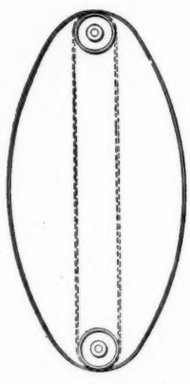


FIG. 3

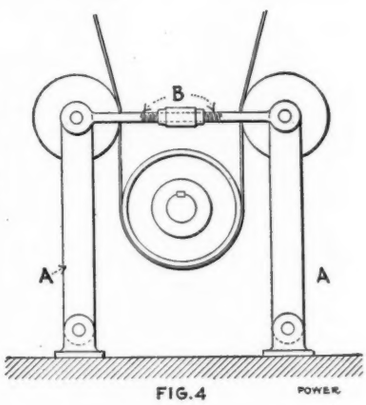


FIG. 4

FIG. 2. SPRING SUPPORT FOR MOTOR

FIG. 3. HOW BELTS TEND TO ACT AT HIGH SPEEDS

FIG. 4. PIVOTED, ADJUSTABLE IDLER

when the belt has left the surface of the idler pulleys. This arrangement will give a very powerful grip, and it has been found that by the addition of this simple device, the power transmitted by a given arrangement of belts and pulleys can often be largely augmented.

Isolated Plant Lights Owenton, Ky.—The city of Owenton, Ky., which was dependent upon the moon for its lighting, has granted a twenty-year franchise and a five-year contract to W. E. Arnold, of that city. Mr. Arnold, says "The Isolated Plant," owns and operates a large flour mill in Owenton, and his power plant is sufficiently large to easily carry this extra load.

ELECTRICAL DEPARTMENT

Induction Regulators

By John A. Randolph

This class of apparatus is used only on alternating-current circuits, its function being to maintain a constant voltage on feeders and rotary converters. There are two general types, the single-phase and the polyphase. In both there is a primary and a secondary winding, one of which is placed upon a movable iron core, while the other is wound upon a stationary core. Either winding may be made the movable element, but the general practice is to place the primary in this position. The primary windings of both the single-phase and the polyphase types are shunted directly across the alternating-current supply mains while the secondaries are connected in series with the respective lines or legs of the system.

The action of both types of regulators depends upon the electromotive force induced in the secondary winding by the current in the primary, this e.m.f. being a variable quantity dependent upon the position of the primary relative to the secondary. In certain positions of the primary the e.m.f. induced in the secondary will be of such a direction and phase relation as to boost or add itself to the generator pressure while, in other positions, the induced pressure will oppose or lower the line potential. This feature comprises the basis for the use of the regulator inasmuch as, during periods of heavy loads and consequent loss of pressure through line drop, the voltage at the center of distribution may be maintained constant by raising the voltage at the station, either on individual feeders or on the station busbars, the latter being accomplished by raising the potential on rotary converters. The feeder-induction regulator is used only on alternating-current feeders, while that used with converters is for the purpose of raising the voltage on the busbars to which direct-current feeders are attached.

The Single-Phase Regulator

This type is generally constructed as shown in Fig. 1. The primary winding is mounted on the movable core and is connected as a shunt circuit directly across the feeder mains. The secondary is placed in slots on the inside face of the stator or stationary core and is connected directly in series with the load. Each winding is so arranged that when in operation it produces an alternating magnetic flux with two opposite poles. The various positions of the poles of the movable primary winding, with respect to those of the stationary secondary, determine the action of the regulator. When the magnetic axes of the two windings coincide, the primary is at either a maximum boost or a maximum lower position, depending upon whether similar or dissimilar poles are opposite each other in position. These conditions can be analyzed by reference to Fig. 2. Let *PP* represent the magnetic axis of the primary and *SS* that of the secondary. In the condition shown, the two axes coincide. It therefore is apparent that the primary field may be made to either coincide in direction with that of the secondary or to directly oppose it by revolving the primary coil through an arc of 180 deg. When axis *PP* of the primary coil is revolved to a position at right angles to the axis *SS*, or midway between the maximum boost and the maximum lower positions, as shown in Fig. 3, the primary field will exert no inductive effect whatever on the secondary winding. This point is therefore known as the zero or "no-boost no-lower" position. The change in the effect of the primary on the secondary takes place gradually as the primary is rotated through the 180 deg. between the maximum boost and the maximum lower positions.

The short-circuiting coil, shown in Figs. 1, 2 and 3, is for the purpose of neutralizing the self-inductive effect of the secondary coil when the primary is at intermediate positions between its extremes and especially when it occupies the zero position. Let the conditions be con-

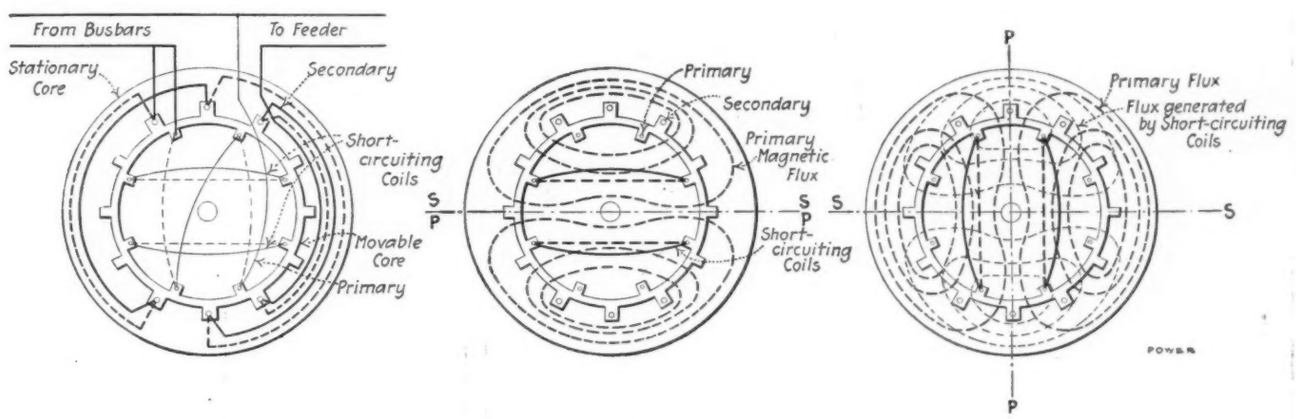


Fig. 1. Fig. 2. Fig. 3.

Induction Regulator Represented Diagrammatically in Different Positions

sidered when the primary is at the zero point, as shown in Fig. 3. At this point the primary has no effect on the secondary. The magnetic field of the secondary is therefore free to pass unrestrained through the primary core. If there were no field to oppose this action of the secondary flux, a heavy electromotive force of self-induction would result which would greatly reduce the active effect of the line potential. The short-circuiting coils are for the purpose of establishing a field which will neutralize the self-inductive tendency of the secondary. They consist of closed coils of wire placed at right angles to the primary coil. By virtue of their position they are inactive when the primary is at its extreme points, owing to the fact that their magnetic axis is perpendicular to the magnetic axes of the two main windings. However, as the primary is moved, the short-circuiting coils are brought gradually into positions where their conductors cut the secondary flux, a current being thereby induced in the short-circuiting coils. This current is at a maximum in the zero position of the primary and, being induced by the secondary field, the magnetic flux of the short-circuiting coils opposes that of the secondary and therefore neutralizes the self-inductive action of the latter.

The magnetic field of these coils in their position of greatest activity is shown in Fig. 3. Their general effect is the same as that produced by short-circuiting the secondary of a transformer. The sum of the ampere-turns of the primary and of the short-circuiting coils should be approximately equal to the ampere-turns of the secondary.

The movement of the primary winding is accomplished directly by hand through the agency of a crank or chain and sprocket; or it may be effected by a small motor controlled either at the regulator or at some point remote from it.

The Polyphase Regulator

The polyphase regulator, like the single-phase type, has two windings, namely, a primary and secondary one, of which, generally the primary is mounted upon a movable core. The polyphase type, however, differs from the single-phase regulator in several important characteristics. One of these consists in the nature of its magnetic field which is rotating instead of alternating as in the single-phase type. Moreover, both its primary and secondary windings are composed of a number of independent windings corresponding to the number of phases in the supply circuit. To produce the rotating field the polyphase regulator is wound similarly to a polyphase induction motor. The speed of field rotation per pole for both primary and secondary windings is the same as that of the generator.

The regulation of the line voltage is accomplished by

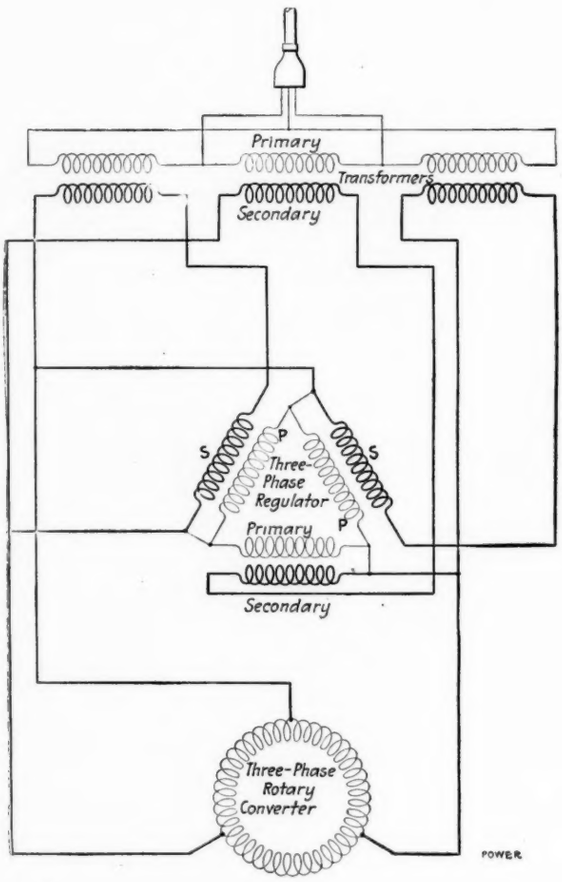


Fig. 4. Induction Regulator Connected to Three-Phase Rotary Converter

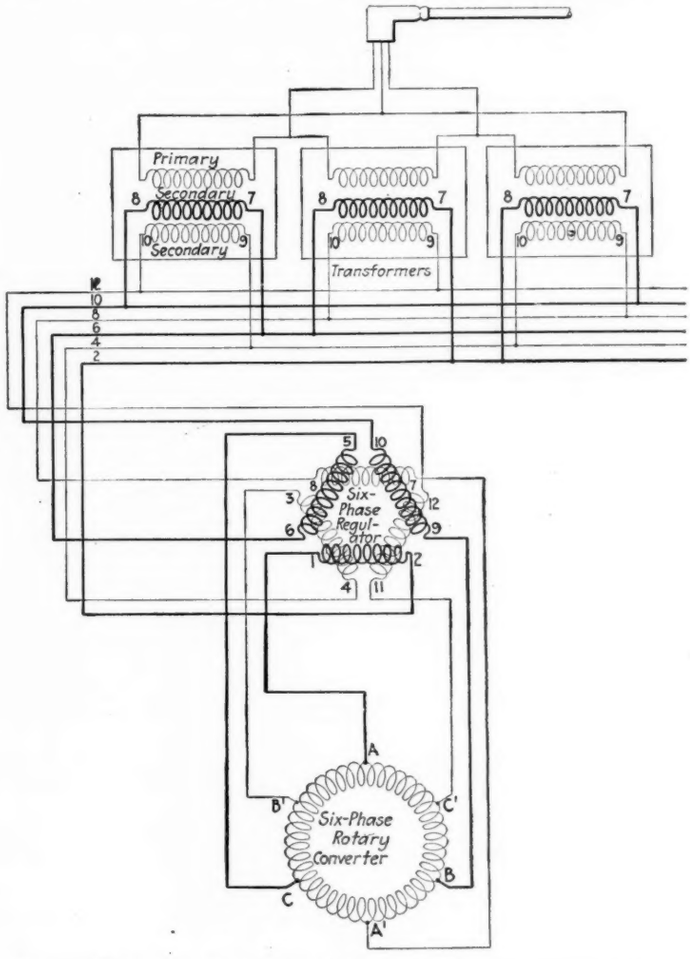


Fig. 5. Induction Regulator Connected to Six-Phase Rotary Converter

varying the phase angle between the primary and secondary voltages by turning the movable winding through various angles. When a given pole of the primary is directly opposite a similar pole of the secondary, the voltage of the primary is opposite in phase to that of the secondary with the result that the voltage induced in the secondary is subtracted from the line voltage. As the movable coil is rotated away from the maximum lower position, the resultant of the line voltage and the induced secondary pressure gradually increases until, when the primary winding is at a position of 90 deg. electrically to the secondary, the resultant becomes equal to the line voltage. This is due to the fact that the primary has no effect on the secondary at this point. As the movable element, however, is rotated beyond the 90-deg. position, the resultant of the line voltage and induced pressure becomes gradually greater than the line voltage until, at the 180-deg. point where the primary pole is directly opposite a dissimilar pole of the secondary, the condition of maximum boost is reached. This occurs because the resultant of the line and induced secondary voltages now become the sum of the two.

The diagram of connections for a polyphase regulator when connected to a rotary converter on a three-phase system is shown in Fig. 4. The connections shown are made according to the delta method. It will be found, upon tracing out the diagram, that each phase of the primary is shunted across one of the three line phases while the corresponding phase of the secondary is in series with one of the legs of the same line phase.

The diagram of connections for the series or secondary winding of a six-phase regulator is shown in Fig. 5. The secondary winding is placed upon the stationary core or stator. The shunt winding carried on the movable core is not shown in the figure. This type of regulator is used in connection with six-phase rotary converters employed on lighting systems. The six-phase converter has a greater capacity than a machine of the same dimensions wound for only three phases. The three-phase transmission, however, is more economical than the six-phase. In practice, therefore, the current is brought to the converter station over a three-phase line and is there changed to a six-phase system by one polyphase transformer or by three transformers, each of which has two secondary windings.

When three transformers are used, the regulator is placed between the transformers and the rotary as shown. The main leads from the transformers pass through the respective regulator secondary windings to the slip-rings of the converter.

Control

The control of regulators is effected by hand or by motor. The latter method, however, is generally used, the motor being mounted at the top of the case and connected by a worm gear directly to the shaft which carries the movable element. A handwheel is also generally provided for shifting the movable element in case the motor is out of service. The motor may be controlled automatically either by a relay used in conjunction with a contact-making voltmeter or by a compensator. The automatic method, however, finds its chief application on feeder regulators. On those used with rotary converters, the most satisfactory method has been found to be that in which the motor is controlled from the main switchboard. This enables the operator to vary the voltage of the converter at will and thus to more easily adjust the voltage of the converter to parallel operation with other machines connected to the same busbars.

The range of voltage variation on induction regulators is generally about 10 per cent. for boosting and 10 per cent. for lowering, making a total of 20 per cent. To secure positive adjustment, the motor should respond quickly to the control of the operator. It should develop maximum torque in minimum time and should stop quickly as soon as the control current is shut off. To accomplish a quick stop a magnetic brake should be used on the motor.

Cooling

Inasmuch as the regulator coils are inclosed, some means of cooling must be provided, as in the case of a transformer, to prevent excessive heating. This is accomplished in one of three ways, namely: by oil immersion, by water pipes in conjunction with oil immersion and by air blast. In the smaller sizes the coils are generally cooled by oil immersion. The oil is contained in a steel tank whose sides are corrugated to present as great a cooling surface to the oil as is consistent with practical construction. In the larger sizes, either the water coils or an air blast is used. With the latter method no oil is necessary. Air cooling is generally used with regulators connected to rotary converters. In this case, the regulator is mounted beside the transformers and receives air under pressure from the same air duct that supplies the transformers.

Efficiency

The efficiency of regulators is fairly high, owing to the small loss of power in the regulator itself. The full load efficiency will generally reach about 95.5 per cent. For a quarter load it will be about 91.5 per cent. The power factor for the various loads varies but slightly and will generally assume a value of about 91 per cent. under ordinary conditions.

❖

A Visible Scale for Torsion Power Meters as used on propeller shafts of steamships is described by Dr. K. Suyehiro, of the Tokyo Imperial University in a recent paper before the Japanese Society of Naval Architects, abstracted in "Engineering." In such a torsion meter, the turning moment is measured by measuring the twist of a certain length of the shaft. A sleeve attached to the shaft at the one measuring point bears a radial arm or a disk, at whose outer edge is a circumferential scale facing inward, a mark opposite the zero point. Halfway between this scale and the center of the shaft is attached a mirror, facing outward, so as to reflect an image of the scale in a nearly radial direction outward. Just beside it is another mirror, attached to the sleeve projecting from the other measuring point of the shaft. These two mirrors reflect images of the scale and of the zero-point mark outward; the geometrical relations of scale and mirrors are such that the images of the scale seen in a viewing telescope appear to be stationary at the center of the shaft. While the image is visible for only a short part of the revolution of the shaft, there will be a sufficiently rapid succession of images to enable the scale to be read.

❖

Argentine Electric Plants—The Santa Fé Electric Tramway Co. is said to be interested in extending its lines 12 miles to the city of Esperanza. A concession will be applied for.

The tramway company in Cordoba which runs a line to San Vicente has applied for permission to extend its present horse lines, and agrees to electrify part of its system.

The government of the Province of San Luis has forwarded a project to the legislature for working an electric tramway, and electric-light and power in the town of Villa Mercedes. It is expected that the project will be approved at an early date.

GAS POWER DEPARTMENT

Utilizing Waste Heat of a Small Gas Engine

In most small gas-engine installations no attempt is made to recover the heat carried off by the exhaust and jacket water. As this available heat amounts to about 68 per cent. of the total heat supplied to the engine, using this heat wherever possible will effect a great saving.

The factory of the Sanitary Water Still Co., Jamaica, L. I., furnishes a good illustration of this statement. Both exhaust and jacket water are used for heating with a resultant saving of about $300 a year. The illustrations represent the old and usual layout and the change that effected the saving. This plant has been in operation for about six months and gives entire satisfaction. The engine is a horizontal 6½x12-in., running at 300 r.p.m., operates on illuminating gas and is rated at 8 hp. It is belted to the shop shafting and has averaged 48 hr. per week for the past three years.

Fig. 1 shows the original installation. The gas was fed to the engine through the usual gas bag, and the muffler was of the baffle-plate type, fastened to the end of the exhaust pipe. A 24x82-in. cooling tank, holding about 160 gal. was set at the engine level and piped on the thermo-siphon principle. Due to the low head, however, the circulation was very sluggish.

The first step to improve the old installation was to dispense with the gas bag with its leaks and yearly renewal. An old hot-water tank about ten times the working volume of the engine cylinder, was put in the gas line, as shown in Fig. 2. The gas is discharged near the bottom and the engine draws its supply from the top. With this arrangement no pulsation of the gas supply is noticeable and leaks and consequent expenses are eliminated.

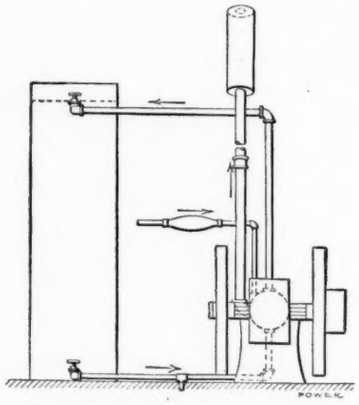


FIG. 1. FORMER ARRANGEMENT

The engine exhaust is piped to the drying closet on the second floor, which contains two racks, each made up of six 1-in. pipes 42 in. long. The exhaust passes simultaneously through both racks on its way to the muffler. The temperature of the lower rack averages 140 deg. F., and the upper 120 deg. which keeps the temperature of the drying closet at about 100 deg.

A 20-gal. hot-water tank serves as the muffler. The open drain, which takes care of the condensation in the exhaust gas, is placed high enough to maintain about 1½ in. of water in the muffler. This assists in muffling

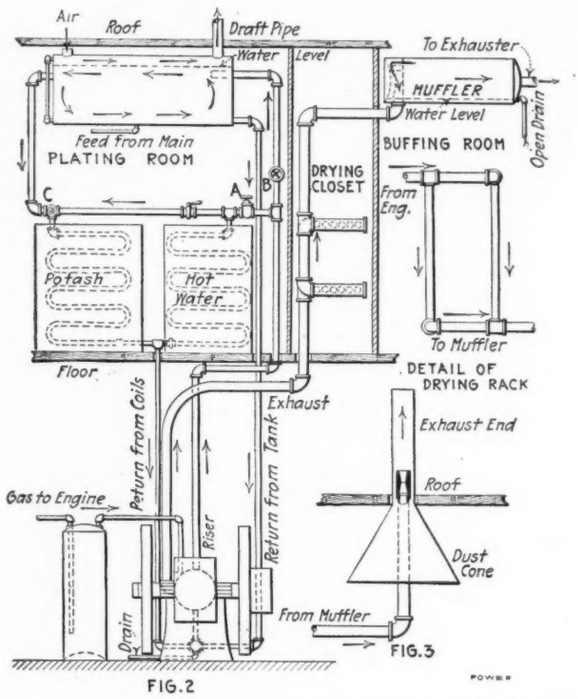


FIG. 2. ENGINE AND TANKS FOR UTILIZING EXHAUST HEAT

the noise of the exhaust. The discharge pipe from the drying racks is carried up in the muffler, to prevent the water from flowing back to the engine. The pipe is capped and partly cut away, as shown, which directs the exhaust against the side of the muffler and breaks up the issuing gas, the temperature of which drops to about 70 deg.

As all the useful heat of the exhaust is given off in the drying closet, there remains only the velocity of the escaping gas that can be converted into work. This is done by means of the exhauster shown in detail in Fig. 3. This acts as an ejector and being placed directly over the buffing lathes, draws out all dust and dirt that escapes the exhaust blower. The exhauster consists of a piece of 2½-in. pipe passing through the roof, which carries a cone made of sheet iron at the end inside of the building. The exhaust discharges into this pipe through the ejector nozzle at the end of the exhaust pipe, carrying along the dust drawn in through the annular opening between the nozzle and the pipe. To get a steady flow of gas the pipe from the muffler is reduced from 2 to 1¼ in., as only practically cold gas passes through this pipe. The reduction does not help much, however; the discharge being intermittent.

The jacket water is used to heat potash in a 24x18x30-in. tank and water in a 18x18x30-in. tank. These tanks are not always in use and provision had to be made to take care of the cooling water in some other way. Space being limited, a 19x50-in. tank was hung to the rafters and piped as shown. With three-way cock *C* and valve *A* closed and valve *B* open, the heated water from the engine rises and is discharged into the top of the tank. There it circulates and is cooled by a counter-current of air passing over the surface of the water. This current is induced by a 2-in. draft pipe, extending 6 ft. over the roof, the pipe acting as a chimney. The air is drawn rapidly through the 2-in. hole on top of the opposite end of the tank, removes the vapor as it rises and carries it along through the draft pipe to the atmosphere. The cooled water returns to the bottom of the cylinder, performs its work and rises to the tank again. The circulation is rapid, as shown by the temperature of the water, leaving the cylinder at 180 deg. and returning at 160 deg. A gage-glass on the tank indicates the water level at all times.

That this method of cooling is very effective is proved by the difference in tank capacity for the same work. This tank holding about 50 gal. does the same work as the old tank of 160 gal. capacity. The manufacturer's specification calls for a 300-gal. tank for this engine.

To heat the water and potash, valve *B* is closed and *A* opened; cock *C* is opened to the coil. Provision has been made to take care of the expansion by connecting the coil return to the return from the upper tank which serves thus as an expansion tank also. The potash is heated to about 100 deg. and the water to 120 deg., while the jacket water averages 140 deg. and the return 120 deg. F.

All combinations needed can be had by manipulating valves *A* and *B* and cock *C*. A faucet for drawing hot water is in the line over the water tank. The pipe on the left of the cooling tank to the coil is used to relieve the coils of air when filling the system, as the filling is done through the tank return; also to heat the potash with water from the cooling tank.

The conditions for a successful installation were rather favorable in this shop, but the novel features introduced and the manner of operating changed to suit local conditions, could be used with profit by many small plant owners. Before the change was made, steam heating was used at a yearly cost of $300. Now, the heat formerly lost gives the same results. The engine, besides driving the machinery, provides the shop with hot potash, hot water, heat for drying and a good exhauster, with the same gas consumption. The cost of the change was $87.40.

Carburetor Troubles and Symptoms

By A. L. Brennan, Jr.

A carburetor is a device for mixing the fuel and air in such proportions that the resulting gas will ignite and form a readily combustible mixture. A good mixture consists of approximately one part of gasoline to 16 parts of air. Of course, this varies to a certain extent with different grades of gasoline and different conditions.

There is no way under ordinary conditions to measure the gasoline or air supply, but with practice the operator should have little difficulty in obtaining a good mixture as the symptoms which point to a lean or over-rich mixture are very marked. Unless the symptoms of faulty carburetion are evident, it is well to look over the ignition and mechanical points before changing the proportion of the mixture, particularly in cases where the motor has been operating regularly.

An overlean mixture will often cause backfiring in the intake pipe or carburetor, although this trouble sometimes results from a leaky intake pipe or float valve, clogging of the float valve or spray nozzle, a defective float or loosened adjustment of the needle or air valve. Much irregular firing can be prevented by periodically cleaning the drip on the carburetor.

An over-rich mixture is usually indicated by dense black smoke and sluggish operation. Also, after-firing in the muffler is sometimes due to an over-rich mixture. Troubles of this nature can be traced to a clogged air intake, too much gasoline through the needle valve or an auxiliary air valve that is stuck. When adjusting a carburetor it is well to have the relief cocks in the cylinders open and observe the exhaust flame while regulating the needle and air valves. A good mixture is indicated by a dark-blue flame verging on violet, which should be accompanied by sharp explosions.

In cold weather it is frequently necessary to obtain an excess of gasoline in the carburetor to facilitate starting. This is done by holding down the "tickler" and thus depressing the float, which allows an excess of gasoline to enter the float chamber and consequently a rich mixture will be formed. In very cold weather it may be necessary to prime the cylinders.

A good mixture is always indicated by a wide range of ignition speeds, that is, with a perfectly regulated carburetor, any advance in the spark will produce a noticeable acceleration in the speed, while if the mixture is poor the spark will have to be advanced considerably in order to accelerate the motor.

The exhaust from a gas engine should be invisible and therefore if the exhaust is smoking, steps should be taken to bring about a remedy. As already stated, black smoke indicates an over-rich or defective mixture, while white or gray smoke indicates an excess of oil. Hence, before attempting to overcome this trouble make sure where the fault lies and act accordingly.

The auxiliary air-inlet valve is usually a ground valve which opens inward, being held in place by a spring of suitable tension. The strength of this spring is carefully determined and is generally set by the manufacturer so that with the proper suction of the motor, as in the event of speeding up, the valve will open enough to allow the required quantity of air to enter the carburetor.

Some gas-engine manufacturers are equipping their motors with kerosene carburetors. Kerosene and heavy-oil carburetors differ from the ordinary variety in that provision is usually made for heating the fuel by some artificial means so that the oil will be raised to a temperature sufficient to insure an efficient mixture. In some cases this change reduces the heat value of the mixture, because the specific gravity of the charge is reduced, and a given volume contains a lesser number of thermal units than when it is at the temperature of the atmosphere. However, good results are being had with kerosene carburetors on gasoline engines, although some trouble is generally experienced when starting. In fact, with few exceptions, engines thus equipped are first started on gasoline, kerosene being fed to the carburetor after the motor has become heated.

HEATING AND VENTILATION

Friction and Inertia of the Heating Art

By James G. Dudley*

The high standards of efficiency being attained today in nearly all fields of human effort, to say nothing of the technical fields of power generation, power distribution, electricity and refrigeration, warrant inquiry as to the cause of the apparent indifference to progress shown by the field of heating and ventilation.

As proof, first of all, that such a negligent attitude exists, it is only necessary to analyze the barrenness of technical advance (in, say, the last 25 years) made in apparatus and the installation of heating and ventilating equipment. Such an investigation must show—in comparison at least with the other branches of engineering—that the gains in efficiency and economy have been of trifling consequence.

Specifications for heating equipments, disregarding minor specialties and the excluded apparatus required for power generation, conversion and transmission, may fairly be reduced to the basic terms of heat generator, heat conveyor, heat dissipator, air exhaust and methods of installation. If ventilation be included there will be in addition air induction, air treatment and air removal.

In justice to the subject, it must be admitted that in this latter department of ventilation an important step in advance has been made within the last two decades, although even its wide adoption is still quite remote, namely, that of air treatment by humidifying, dehumidifying, cleaning and cooling with water. Aside from this single exception, what have been the gains in efficiency and economy in the warming of buildings during the last 25 years? For answer examine the market and the records; (1) of the generators of heat, (2) of the conveyors of heat, (3) of the dissipators of heat, (4) of air exhaust and (5) of the methods of installation involved in the warming of the multiform sizes and types of buildings, whether by steam under low pressure, vacuum or vapor or by water circulated by pump or by gravity.

Generators of Heat

In those designed for power generation with heat delivered at reduced pressure or as a byproduct, it is safe to say that the gains in efficiency and economy whether sought in the mechanical structures or in the processes of combustion within them are negligible or at the best would not exceed a minute percentage. In that class built exclusively for low-pressure heating careful investigation will verify the astonishing fact that excepting one (or at the most two or three) all are actually less efficient than their lineal ancestors of 25 years ago.

The notable exception referred to originated fully 20 years ago, and its sole warrant to be considered an exception in this investigation lies in its increase in economy owing to a design of grate which permits of the burning of sizes of coal smaller (hence cheaper) than domestic sizes.

Conveyors of Heat

Neither in efficiency nor in economy have there been gains in the means employed for conveying heat from the generators to the dissipators other than a small reduction in pipe sizes selected by the majority of designers of heating systems. Even from a commercial standpoint there has been back-sliding in quality of product over that obtainable more than 25 years ago, purchase price always excepted.

Heat Dissipators

This term has been employed in preference to the conventional one of "radiator" for reasons of technical accuracy. Here we find but a single step in advance, whether measured in efficiency or physical advantages, the latter applying more directly to recent designs. This is the substitution of sheet metal for cast-iron construction, dating back at least a decade ago. The advantages are a saving of from one-half to three-fifths of the space occupied, of two-thirds of the weight and of one-fourth of the cubic contents. Necessarily this last item makes for quicker action as a heat dissipator in warming up and cooling down, although it is unquestionable that the net output of thermal units must be equal for dissipators of equal rated capacity under constant conditions of heat supply.

The importance of the above advance is minimized when it is learned from trade records for 1912 that the total output of the sheet-metal dissipator for that year does not equal one-half of 1 per cent. of the annual output of the conventional cast-iron type.

Air Exhausting

One of the most serious of the elements opposing high efficiency in heating systems is the contained air which must be exhausted from the system. What have been the gains here over those which were in use 20 odd years ago? The acid test of cold mathematics would play sorry havoc, it is feared, with most of the efficiency and economy gains claimed by the multitude of advocates of vacuum steam-heating systems now appealing for supremacy, but it would not be difficult to secure from the veterans of two decades ago data of systems then existing, which would quite confound the claims, even with mathematical analysis left out of the question. Of vapor heating little need be said supplementing the above broad contentions nor of low-pressure steam with gravity returns. When we turn to the gravity system of heating with hot water as the conveyor medium, not a single gain in efficiency and economy in the methods and apparatus for exhausting the contained air has "seen the market" superior to those which were known and in use by the old timers.

*Consulting engineer, New York City.

Method of Installation

Under this head may be gathered all the accepted means employed by the designers of heating systems to accomplish the results desired. As the heating art has evolved, the best practice has been handed on and down from one to another—much as is the token by the runners in a relay race—without challenge of the basic facts and formulas until today accumulated experience apparently governs where mathematical certainty should blaze the way.

What gains in efficiency and economy have been won in the last two and one-half decades by "skill and experience" in the warming of buildings? Low-pressure steam, vacuum and vapor heating have been weighed in the balance and, it must be confessed, have been found wanting on the points in question. So called gravity circulated hot-water heating has scored apparent gains in the last decade by the reduction of pipe areas, but as a matter of fact piping equally small was employed in installations equally large (if not as numerous) more than 20 years ago.

Pump-circulated hot-water systems operated in connection with power plants have been installed for more than 20 odd years but in limited numbers. Inherent lack of efficiency or economy has proved one limiting cause of this result when the heat generator was a hot-water boiler or a high-pressure steam heater. Another limiting cause of this lack of adoption has been an all too exclusive policy of exploitation in the case of the highly efficient and economical patented system which employs exhaust steam for the main source of heat supply.

From the foregoing analysis it is evident that little, if any, real gains in efficiency and economy in the apparatus and methods of warming of buildings have been made in the last quarter of a century. This has been due to a great extent to the friction of vested interests and the inertia of custom and prejudice.

"Vacuo" Hot-Water Heating

Is it for this reason that "vacuo" hot-water heating, which marks an epoch in the warming of buildings from plants generating their own power, has not received the attention that it deserves? The lack of response to the mathematical analysis of this system might reasonably be excused in other days, but at the present it would almost give warrant to a charge that there exists a "conspiracy of silence" to suppress its good points. However, let it be charged rather to friction and inertia.

For those who have not read the numerous articles in Power on this subject the following résumé is submitted: "Vacuo" hot-water heating comprehends that branch of pump-circulated hot-water heating in which the heat generator comprises primarily a special type of water heater whose source of heat is the steam wasted from prime movers, engine or turbine, preferably the latter, operated condensing as the result of the cooling action of the heat dissipators employed for warming the building, supplemented by a cooling tower and condensing apparatus of sufficient capacity for the surplus of power over heating during winter and for all the power in the nonheating season.

The essence of this system is the production of a high vacuum by the cooling action of the heating system. In practice a well designed installation should average approximately 20 in. of vacuum during the heating season, and thereby secure the additional economy to be obtained by running condensing instead of noncondensing, the latter being the universal method which obtains in such plants not equipped with the "vacuo" system. The vacuum thus produced is under simple manual or automatic control whereby it may be varied at will throughout the entire scale to vary correspondingly the heat content delivered to the water circulated throughout the heating system. There is thus secured a sensitive means of temperature regulation without the employment of thermostatic control and pneumatic valves and piping, as is the case with steam heating.

"Vacuo" hot-water heating contrasted with vacuum steam heating permits the treatment of combined heating and power installations as a single problem instead of a dual one, and secures higher efficiency not only in the generation of power but also in the heating system itself. All or a part of the power load, as far as may be practicable, is balanced against the varying size and character of the heating load, the surplus being treated almost as a separate condensing problem.

A "Vacuo" hot-water plant of 100,000 sq.ft. of radiation coupled with a continuous power output averaging in excess of 500 kw. has been operating continuously for several years past with an average vacuum in excess of 20 in. maintained at the turbine units during the heating season solely by the condenser action of the heat dissipators employed for warming the group of buildings served. Necessarily the efficiency has been high and the economy, when the power has been in excess of the heating, has exceeded by fully 25 per cent. not only the best that has been, but the best that can be achieved by any vacuum steam-heating system with power generators run noncondensing.

All this evidence and much more of like character supplementing it has repeatedly been presented within the past year or two to the designers of other such plants not only indirectly through the technical press, but directly and with especial reference to concrete installations in the preliminary stages of their planning. The system has been denied serious consideration up to date, apparently upon the grounds made famous by the son of Erin, who remarked—after contending in vain against the truth of the descriptions and reproductions of the stately giraffe—that "there was no such animal."

Even if no operating plant had been installed showing by its detailed and accurate records the high efficiency and economy of "Vacuo" hot-water heating, the thermal and thermodynamic exposition of its soundness should have won recognition long before this. The underlying theory cannot be denied. The established facts cannot be controverted. The practical experience out of which the system has been evolved is unique and on a parity with that acquired by any designer of heating systems in this country or abroad. The indorsements won from candid and competent technical authorities after exhaustive investigation are of the highest character.

If the technical world concerned with the design of efficient and economical plants for the warming of buildings served from isolated or central power stations is to avoid the charge of "intellectual ossification," or "a conspiracy of silence," the time is opportune to avoid either horn of this dilemma by indorsement or denial.

Piping Costs Favor Hot-Water Systems

By W. L. Durand

In the United States a forced hot-water installation seems to be the exception rather than the rule. This is presumably due to the fact that the advantages of hot water over steam are not generally known and recognized. Also that, in most cases, a comparison of the costs of the two types is not made, and where low first cost is desired it is assumed that steam is much cheaper and it is installed without any investigation of a hot-water system. The following comparison of pipe-size schedules may be of interest in showing that the piping for a forced hot-water or a one-pipe steam installation would not be far different, while for a two-pipe steam the difference in cost would be in favor of the hot water.

The following table gives the radiation for each size of pipe from 1 to 10 in. for steam mains with a drop of pressure of 1 oz. per 100 ft., for returns and for forced hot water based on 170 B.t.u. per sq.ft. per hr. and 20 deg. drop with a friction head of 2 lb. per 100 ft. This represents the friction head for an average job:

CAPACITY OF PIPES IN RADIATING SURFACE

Size of Pipe, In.	Sq. Ft. of Rad. Supplied		
	Steam	Return	Hot Water
1	40	400	270
1¼	75	750	570
1½	150	1,500	830
2	300	3,000	1,720
2½	500	5,000	2,630
3	900	9,000	4,650
3½	1,500	15,000	6,800
4	2,000	20,000	9,500
4½	2,800	28,000	12,600
5	3,600	36,000	17,000
6	6,000	60,000	27,800
8	13,000	130,000	57,000
10	25,000	250,000	100,000

Assume a system containing 25,000 sq.ft. of radiation. This would require a 10-in. steam main and a 4½-in. return or two 6-in. hot-water pipes. The cost per foot for the pipe would be about $1.75 for steam and $1.10 for hot water, or a saving of about 30 per cent. in favor of hot water.

Insulation of Underground Steam Mains*

To show the value, in dollars and cents, of efficiency in underground insulation, a section of underground steam main insulated with standard materials that will show a loss of 0.034 lb. of steam per sq.ft. of surface per hour will be compared with a line insulated with a construction that will show a loss of 0.14 lb. per sq.ft. per hour. Both these constructions are found in everyday practice.

For this purpose take an 8-in. steam line 1000 ft. long. An 8-in. pipe has 2.25 sq.ft. of surface per lineal foot. With a radiation loss of 0.034 lb. there will be in 1000 ft. of main a line loss amounting to 76.5 lb. of steam per hour. In the second case, with a radiation loss of 0.14 lb. the line loss will amount to 315 lb. of steam per hour. Assume that to generate and distribute this steam will cost 30c. per 1000 lb. This will give in a season's operation (season assumed from Oct. 1 to June 1, 5832 hr.) a line loss in the first case equal to $133.84 per year, and in the second case equal to $551.12 per year.

*From a paper read by H. C. Kimbrough before the Kansas Gas, Water, Electric Light and Street Railway Association.

The money saved, therefore, on the line loss will be the difference between $551.12 and $133.84, which is $417.28 per year. This money is 6 per cent. on $6954.66, which is the amount of additional money that can be spent to properly insulate the underground construction. On the 2250 sq.ft. of surface in the 1000 ft. of 8-in. main it will be seen that for every 0.01 lb. of steam saved per square foot per hour, approximately $700 can be spent or 31c. additional cost per sq.ft. of underground mains. This amounts to 70c. per lineal foot of 8-in. main.

Cost of Heating and Power-Plant Apparatus

I have examined with much interest the cost figures given by Mr. Downing in the Nov. 18 issue. Figures of this sort are of great help in getting up approximate estimates of work, although they must be used with discretion, since for the same apparatus prices vary over a wide unit range depending on the size. Also, any item affected by the cost of labor, will be subject to variations depending on the locality.

Temporary setting of direct radiators, $2.25. This item depends entirely on local conditions and the use of any definite price would be misleading unless it were known to apply to the particular locality. For instance, in New York City the standard prices for connecting temporary radiators is $4.50 for a single-pipe job and $5 for a two-pipe job.

The allowance of $50 per thermostat is misleading, as there is no direct relation between the number of valves and the number of thermostats. The use of the following figures would give much closer results. They include all piping, etc.:

Thermostats	$25
Valves	10
Mixing dampers and diaphragm motor	20
Air compressor	125

Cast-iron sectional boilers cost from $28 per sq.ft. of grate surface for a boiler which will serve 300 sq.ft. of radiation to $24 for a boiler rated at 9000 sq.ft.

Shaking or dumping grates cost from $4 to $4.50 per sq.ft. instead of $5 to $6.

A vacuum system complete, including pumps and accessories, will cost from $7 to $10 per radiator installed complete, but the valves themselves may be purchased for $4.50 to $5.

The following are the average costs for steel-plate fans, motors and engines for fans from 4 to 8 ft. in diameter and delivering air up to ¾ oz. pressure:

Fan per 1000 cu.ft. per min	$12.50
A. C. motor, per hp	18.50
D. C. motor, per hp	23.00
Inclosed high-pressure engine, per hp	17.50
Inclosed low-pressure engine, per hp	33.00
Open high-pressure engine, per hp	14.00
Open low-pressure engine, per hp	27.00

The cost of air washers at $18 to $26 per 1000 cu.ft. of air per min. at 500 ft. velocity is incorrect. They cost from $50 to $60 per 1000 cu.ft. installed. Two recent installations cost $1200 for 22,000 cu.ft. per min. and $2800 for 50,000 cu.ft. per min.

Concrete foundations for engines will cost $9 to $10 per cu.yd., including sand cushion.

Sprinkler systems complete, including tanks, pipe, heads, pump and erection, cost about $7 to $8 per head.

W. L. Durand.

New York City.

EDITORIALS

The Fireman's Task

The fireman's task is twofold: to secure capacity and economy. First and most important, the steam pressure must be kept up. A good fireman keeps the steam pressure within the limits (generally very narrow) of allowable pressure variation. Could he, without a steam gage, tell whether or not he was holding the pressure? Is there an engineer or superintendent of a boiler plant who would expect him to do it?

The second important part of the fireman's task is to generate the greatest possible amount of steam per pound of coal fired. Does he succeed in doing this? Not at all. Do you expect him to do it? Yes. But what help or guide do you give him? You set a standard of steam pressure to be maintained and give him a steam gage to guide him, and he makes good on this portion of his task. Unfortunately, he does it by sending 30 or 40 per cent. of heat up the chimney, whereas this waste should not exceed 20 or 25 per cent. So long as he has nothing to guide him, no means of knowing whether he is wasting much or little, or when he is working wastefully or economically, so long as he is working blindly, he cannot be expected to make good on the second part of his task and he doesn't.

Set the standard and give the fireman the means of knowing what he is doing and he will make good in the direction of economy as well as capacity.

The percentage of CO_2 is an index of efficient combustion and, in combination with the temperature of the escaping gases, is a measure of the heat wasted up the chimney. Therefore, as one means to the desired end the fireman could be provided with a gage showing the percentage of CO_2 as prominently as the steam gage shows the pressure and the water glass shows the water level.

The fireman sees the hand of the steam gage dropping below the required pressure and he immediately attends to his fires. He shovels more coal, and opens the damper (if that is within his control, but only too frequently it is not), he shakes the grate, slices the fire, he does one, several or all of these things, as his experience and judgment dictate as necessary or expedient, and keeps at it until the hand on the steam gage moves the other way. Whether he is firing economically or wastefully he does not know. He has no means of telling whether he is burning the coal with 30 or 40 per cent. excess air, which is entirely sufficient, or whether he is chasing 100, 200 or 300 per cent. too much air up the chimney. He cannot tell and the chief can only suspect it from the coal bills.

If the steam rises above the specified pressure he stops shoveling coal. He may close the damper or not as suits his convenience. Allowing the fire to burn thin permits a large volume of air to pass through the fuel. This air carries away the heat—wastes it—and the generation of steam is checked. The latter is what he was after. He must not let the steam pressure exceed the limit set. He may even find it expedient to open the fire-doors occasionally. Again, he wastes the heat by sending a large volume of highly heated excess air up the chimney.

He knows he must keep the steam pressure within prescribed limits or lose his job. The steam gage enables him to do this and he does it. The fireman knows that you know and that is the principal reason why he makes good.

There are some firemen of an observing mind who use their brain to save their muscle. They have found by experience that by keeping an even fire bed, by preventing holes from burning through, by adjusting the fire thickness to the available draft, or adjusting the draft to the thickness of fire necessary to keep up the steam pressure, by stopping up leaks in the setting, etc., they can reduce the labor of shoveling coal and hence keep up the required steam pressure with less exertion. The great majority, however, do it by main force and stupidity. All they know is that if the steam pressure drops they must shovel more coal, and if it goes above the required mark they must shovel less. Such firemen waste several times their wages in coal every day; but you have no means of telling which of your firemen are firing more and which less efficiently. Only too often the man who shovels the most coal is considered the best fireman, when the reverse is more likely to be the case.

Under these circumstances it is much more surprising that occasionally a boiler plant reaches an efficiency of 75 per cent. than that the average does not exceed 65 per cent. There is no good reason why under fairly favorable conditions an average efficiency of at least 75 per cent. should not be maintained.

To attain and maintain maximum efficiency you must provide the fireman with a means of knowing what he is doing, you must set a standard to be worked to and you must provide yourself with the means of knowing how well the fireman succeeds. The fireman must be aware that you know when and how much he falls short. Thus provided with the necessary guide and moral incentive the fireman will make good in the second part of his task as well as in the first.

❋

The Shirk

In many small steam plants, running day and night, is found the shirking engineer. He is the type of man who goes off watch leaving a dirty engine, empty oil and grease cups and half-filled lubricators or oil tank. The drip pails and pans are filled to overflowing, and often much needed adjustments or repairs are neglected, and his relief must do the shirk's work to keep the plant going. In the boiler room there are thick, unclean fires, low water and filled ashpits. The gage-cocks leak and the water glass is covered with lime, or the lamp back of the glass has burned out or been broken. Perhaps the pumps should have been packed but are left to leak and blow.

And he glories in the fact that he can do these things. He is able to do them not only because he is a shirk, but because the relief engineer is watchful, neat and painstaking, and his proper pride compels him to do double duty in this respect.

Of course, the shirk, after the manner of his kind, delights in "putting it over," and for a time he thinks he is a very clever individual. But after a while he is informed that a new engineer will stand watch in the place of the old one; the latter has secured a better position. Eventually, the shirk, if the new man will not be imposed upon, becomes sour and disgruntled, and in most cases soon finds his level in a little plant where he is still the "engineer," but between times wheels his own coal and cleans his own fires.

The remedy for this condition is mainly in the hands of that engineer who has the firmness to refuse to accept any imposition from the shirk. He makes it plainly understood at the outset that, while he wants to do everything possible to prevent friction, to establish pleasant relations with his fellows and to help gain the commendation of the owners by good service—in the same plant with him there is no room for the shirk.!

These are some of the reasons why no engineer should take exception to the man coming on watch, satisfying himself that everything is in proper operating condition before he assumes charge. It should be plain that his precaution is an added safeguard for both of them, and cannot sensibly be taken as reflecting upon the skill or care of the engineer about to be relieved. The careful buyer counts his change, the careful seller expects it; it is a check upon the element of error that may enter into their transaction. A straight cashier never resents having his accounts audited.

Welded Joints

If metal could be joined by welding so that the joint was known to be as strong as the metal itself, the riveted joint with its lack of symmetry and loss of strength could be done away with, and pressure vessels be made neater, lighter and safer than by the process of metallic stitching now in general use.

Many welded joints have been tested in which the piece broke in the solid metal outside of the weld, and many others in which the failure of the weld showed a tensile strength nearly equal to that of the metal of the sheet. But this is not *a priori* proof even that the welded joint can be made safe. In the autogenous process of welding there is a line or a film of molten metal interposed between the welded surfaces. This metal comes from the meltbar or welding wire which the workman fuses with his torch and runs between the heated surfaces of the metal to be joined. What is the character of this metal after it has been melted, run and allowed to set without working? What is the effect of the heating process upon the edges of the sheet itself? What internal stresses are set up by the intense local heating and cooling? Is the joint given a high tensile strength by one or more of these causes to the detriment of some other quality?

These observations are not intended to throw distrust upon the welded joint as used for a rapidly increasing number of purposes, but are prompted by the extreme caution which should control the extension of that use to vessels of considerable size under pressure and containing large amounts of stored energy. That ninety-nine per cent. of the joints so made were as strong and reliable as though the metal were continuous would not qualify the process if it were impossible to say which one of every hundred boilers might have the defective weld. A riveted joint is at least safe to start with. What is needed is a means of telling whether a welded joint is all right by some process other than the destruction of the joint.

In Germany a search is being made for such a process. In response to an offer of a prize for the best method, twenty-six contestants sent in suggestions. None of these in the opinion of the board of expert judges offered a complete solution of the problem but five of them offered possibilities and will be tried out. (See page 944.)

Some of those who are doing autogenous welding successfully and who know that it can be done so as to be perfectly safe and satisfactory even in the longitudinal joint of a large boiler shell are impatient of this research, and doubtful of the finding of a method which shall be at the same time reliable and simple enough for commercial use. Henry Cave, in a paper abstracted on page 940, contends for a "three-license system" under which the apparatus, the operator and the party undertaking the work shall all be examined and licensed. It is apparent why the apparatus and operator should be approved, but the operator while he may be skilled in the use of the torch is usually not a judge of the best materials to be used on a particular job, whether or not heat treatment is necessary, whether in a complicated structure the piece is in compression or tension, etc.

Autogenous welding is being successfully used on many comparatively large fittings under pressure. Lengths of steam main and even receivers for engines of considerable size are made with the fittings welded in and the receivers, we believe, with welded seams. We should be quite willing to accept as safe a joint which Mr. Kautny or Mr. Cave had made or seen made. Perhaps it may do to depend upon men who have the certified approval of these or other competent authorities. But we shall all feel better about it if they find that simple, practical, positive method of telling whether the weld is sound.

Credit to the Central Station

While the efficiency methods as applied to the workrooms of mills and factories influence the economy of the power plant, it must be recognized that the central-station companies more than industrial efficiency engineers, are the ones who have furnished the conditions that stimulate most isolated-plant engineers to greater effort.

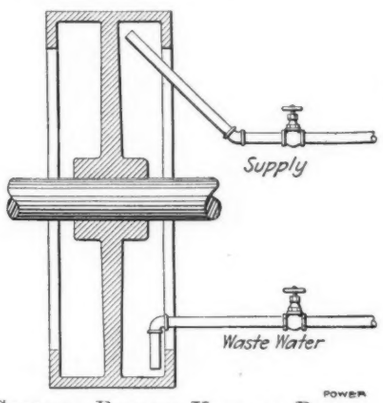
A central station is a competitor of the smaller plants in the same locality. As it sells power for profit its methods of power generation and transmission are usually efficient and thoroughly systematized. They should and must be. The central station as an institution has forced power-plant engineers, as a class of labor, to better efficiency just as any competitor who adopts improved methods forces others in the same business to do likewise.

By the foregoing we do not mean to infer that progressive engineers are rare. Thanks to the inherent thoroughness, some engineers conduct their plants in a manner comparable with the best managed central stations. These men are pioneers, are vanguards to the host of others who must be told to follow.

READERS WITH SOMETHING TO SAY

Cooling Prony-Brake Pulley

In preparing to take the brake horsepower of an automatic engine I noticed that the governor pulley had inward-projecting flanges at the rim. The prony brake was applied to this pulley and the rim kept cool by a small stream of water applied to the inside of the rim, as shown in the illustration, which does not, however, show the governor mechanism. The outlet pipe had to be carefully fitted to avoid striking the blocks and levers of the governor and still be close enough to the rim to suck out the water before it overflowed the flanges.



COOLING PULLEY USED AS BRAKE

This arrangement may be used with any pulley which has suitable flanges. If very much water is used or extreme accuracy is desirable the stream of water should be projected in the same direction as the rim is traveling and at the same speed. Otherwise the rim would use some of the power of the engine in bringing the water up to speed.

FRED BOONE.

Davidson, Okla.

Heated Air for Steam-Boiler Furnaces

Some years since a series of experiments was conducted to determine the value of a heated-air supply for steam-boiler furnaces. These experiments were financed by an association of mill and factory owners and extended over a long period. They were very thorough as well as expensive and showed that about as much could be gained by heating the air supply to the furnace as is gained by heating the feed water to a boiler by some source of heat that otherwise would be wasted. In extreme cases the saving was as much as 14 per cent.

This being the case it becomes an interesting question as to why this method of economizing is not more generally used than it is at present. Is it because of lack of knowledge of the benefits to be derived, or is it because of the expense of fitting up the proper apparatus, such as was needed in the experiments referred to above, or is it because this question has never been pressed home to the people who pay the fuel bills? Great expense is incurred to save every possible heat unit for the feed water and to this end elaborate economizers are installed between the boilers and the stack, and steam traps are used to return the hot water to the boiler without undue loss of heat. All of this is commendable if done properly, but the heating of the air supply to the furnace seems to be a mine of wealth practically untouched at present and one that seems to be worthy of serious consideration.

Aside from the experiments and tests above referred to and as a side light on what effect the temperature of the air has on the economy of combustion in everyday practice, it may be stated that some years since a series of tests on an internally fired boiler were made by four well known experts. These men were and are all members of the American Society of Mechanical Engineers and the tests were run in accordance with the code of rules approved by this society.

The tests were made at different seasons of the year. Each test was under the direction of a different expert, but all weights, etc., were taken by the same assistants and the boiler was fired by the same skillful fireman. In fact, all the conditions with the single exception of the temperature of the air were as nearly alike as they could be made. The highest duty was obtained in the warmest weather and this in a way confirms the theory that the temperature of the air supply has an appreciable effect on the duty obtained.

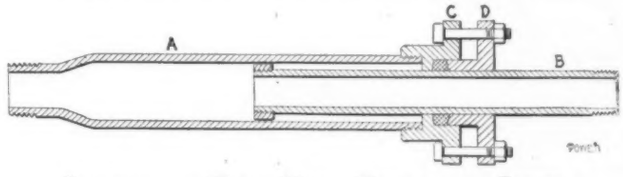
W. H. ODELL.

Yonkers, N. Y.

Home-Made Expansion Joint

The accompanying sketch shows a 3-in. expansion joint which is practical in service and economical to manufacture and has an advantage over the type usually made in that it may be made for any length of stroke without great additional expense.

The sleeve *A* is a piece of 4-in. pipe with a standard thread on one end and swaged to 3 in. with standard 3-in. thread on the other end. The plunger *B* is a piece of 3-in. pipe and has a standard thread on each end. One end is for the pipe coupling and on the other end is screwed a short ring to prevent the plunger drawing entirely out of the joint. This plunger is trued up and polished on the outside between the threads. On the 4-in. end of the sleeve *A* is screwed the flange *C*, which is bored out for packing and fits over the plunger *B*. The flange *D* forms the gland for the packing box and is bored to fit freely over the plunger *B*. Both flanges (*C*



SECTION OF HOME-MADE EXPANSION JOINT

and *D*) are drilled for four ⅝-in. bolts for drawing up the packing. Plunger *B* is free to slide back and forth the distance between the coupling on one end and the ring on the other.

I have made several of these expansion joints recently and they are giving good satisfaction.

L. E. Stephens.

Fellows, Calif.

A Pump-Valve Kink

With some types of pumps and valve designs it is very trying to screw the spindle fast and at the same time hold the spring and cover plate from falling down into the pump chamber. To obviate this trouble, I use a strip of

Tool to Hold Pump-Valve Spring

$\frac{1}{16}$-in. sheet brass, about ½ in. wider than the valve stem, and slotted as shown.

By compressing the valve spring when it and the cover plate and valve are on the spindle, and by getting the inside edges of the slotted brass strip in the threads of the spindle, the latter may be easily screwed fast.

J. M. Coleman.

Manchester, Eng.

Cause of Knock in Pump*

Reading the experiences of Mr. Hurst and Mr. Ferguson on the cause of knocks in pumps, I wish to relate an experience I recently had with two 8x5x12-in. boiler-feed pumps. These pumps are of the duplex type with packed pistons. The valves used are standard composition as generally used for hot water on feed-pump service. No. 2 pump had been overhauled and two new piston rods put in. When the pump was again put in service it worked good at first, and after a few days it worked well at slow speed, but on speeding up both pistons would jump about an inch at the beginning of each stroke. To all appearances either the steam piston or water piston was loose on the rod. As new rods had been put in it was thought possible that they might be a little loose.

The water end was opened and the nut on the end of the rod tried and found tight. Then the steam cylinder was opened and the nut on the steam end found tight. To make sure that the trouble was not in the piston rods one was taken out and the water piston fitted on it and proved to be a good fit. The rod was then put back in place, and repacked, and the cover taken off the valve chamber where the cause was apparent. Here it was found that three of the suction valves and two of the discharge valves were binding on the stem so tightly that they would be held open against the action of the spring until the reversal of the direction of the water through the ports together with the tension of the springs closed them. That was what caused the quick jerk at the beginning of the stroke. These valves were a good fit when put in, and must have expanded on being heated up after a long shutdown. They were bored out about $\frac{1}{32}$ in. and put back in place and no further trouble occurred. The only part that is not clear is that inasmuch as these valves were in use several months after they were put in and gave no trouble of this kind, when the pump was started after a shutdown of two months five out of the eight valves were tight. No. 1 pump was overhauled at the same time, and had been in use about six weeks when the same trouble occurred in it as in No. 2. Two suction and two discharge valves were found stuck on the stems, and after being bored out, stopped the knock.

It has been my experience that as a rule the larger part of trouble in pumps can be traced directly to the valves. It may be due to excessive leakage, or a broken valve, broken spring, stud breaking off or working out, valves too tight on the stem, or gasket between the suction and discharge-valve deck blown out, any of these conditions will cause trouble, and may cause a heavy knock which appears to be and actually is in the cylinder, but the cause of it will be found in the valve chamber. If the suction pipe is long, or its opening restricted or the lift is high the pump may knock when running at high speed, but this knock will be of a different nature than that caused by defective valves and would not be mistakened by the engineer.

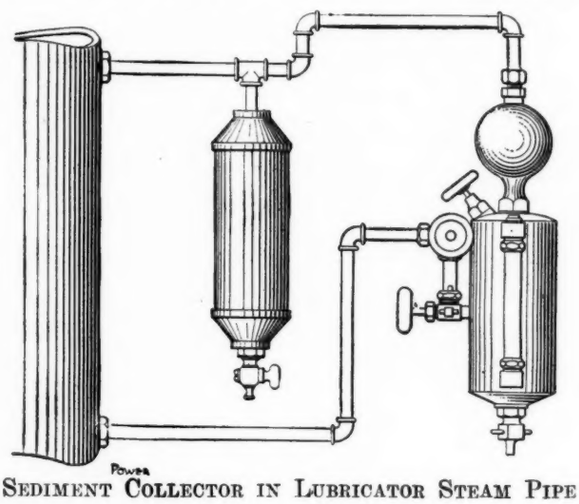
J. C. Hawkins.

Hyattsville, Md.

*"Power," Sept. 16, p. 404, Nov. 18, p. 727.

Sediment Collector for Lubricator

The lubricator is a sensitive and delicate apparatus, and, therefore, any sediment collecting in the oil and water tubes or pipes will undoubtedly cause trouble. Trouble is more likely to occur when the feed water is



Sediment Collector in Lubricator Steam Pipe

treated with chemicals, such as soda ash, on account of the foaming of the boilers.

An inexpensive attachment, which will provide a protection against the collection of sediment in the lubricator, is illustrated. A few extra pipe fittings are needed to make the collector for the steam connection to the lubricator, reducers being used on each end of a pipe forming the body of the collector. By opening the small drain cock at the bottom of the collector, the sediment may be blown out very quickly.

T. J. M. Clute.

Schenectady, N. Y.

The Effect of Air in Feed Water

Mr. Boone's letter, in the issue of Nov. 25, is interesting in that it calls attention to the possibilities which lie in the future development of power apparatus wherein the working fluid is a mixture of a vapor and a gas, for instance, as in this case, steam and air. It is not necessary at this time to enter into any discussion as to whether those possibilities are attractive or otherwise. It is enough to note that in the development of the gas turbine, it has been proposed, among other methods of attacking the problem, to combine the generation of steam with the production of the gas, and to expand them both together.

So far as the discussion referred to is concerned, it looks as if the advocates of the open heater had the best of it, because their argument was certainly based upon undoubted fact, while that of the other side involved some incorrect assumptions.

In the first place, pumping air into the boiler with the water was not accomplished without throwing any more work on the feed pump. The pump simply acted as a combined water pump and air compressor, and the theoretical work chargeable to each function could be ascertained, knowing the relative quantities of water and air. Therefore, the air is not "compressed into the closed heater and boiler without any expenditure for power."

In the second place, while it is true that "it requires no heat to evaporate it as it is already in the form of a gas," it does require heat to bring it to the working temperature, and the fact that its specific heat is less than that of water is not the advantage it appears to be. As a matter of fact, to transform heat into power, the working fluid must be put under pressure and then allowed to expand. With a vapor, the pressure is obtained by boiling the fluid, the process entailing a loss of the heat used in changing from liquid to vapor. With a gas, in order to keep down the size of apparatus, the pressure is obtained mechanically at a considerable loss of energy, by means of a compressor, rather than by the application of direct heat.

Now, the average compressor will put into the gas it compresses, about one-half of the energy consumed by it. The operation of a steam pump as a compressor might show something like this efficiency, if it happened to be the right kind of pump, but it would be safer to assume a greater loss than that stated.

Through the same temperature range, the theoretical work done by the air in expanding will be equal to the work done upon it by the compressor, but, it has taken double its stored power to compress it, therefore, even if its expansion were 100 per cent. efficient, it could only deliver half the power put into it. So far, then, the pump is putting into the system twice as much energy as is realized.

Of course, there is a gain due to the difference in temperature of the air in the heater and the air in the boiler. This would not in practice amount to more than 300 deg. F., and would not represent sufficient gain in volume to make up for the loss in compressing.

The matter of the different specific heats does not enter into the problem, because the same specific heat applies both to the expansion and the compression of the air, and the theoretical power thus put into or taken from a gas, depends upon its particular specific heat.

Putting the air in at low temperature, that is, compressing efficiently, expanding from as high temperature as possible (superheat) and running condensing (sounds impossible, but it is possible with modern types, by simply making provision for handling more than the traditional 10 per cent. of air), will make such a system more nearly possible, but even then it will be found better to keep the air out, until much higher temperatures are possible than we dare use today.

There is one feature that deserves mention; that is, that when any considerable amount of air is mixed with steam, the mixture becomes unsaturated, though it may be at the temperature of saturated steam for that pressure, and, in expanding, condensation will not take place until the mixture has reached its "dew-point." As the temperature of total condensation of such an atmosphere is not reached short of the freezing point, investigation along these lines presents some interesting problems as to what additional power is realized from the combined expansion of a gas and a vapor, as distinguished from the sum of their expansions taken separately.

R. Carpenter.

East Orange, N. J.

Safety-Valve Problem

H. H. Hastings, in the Nov. 18 issue, relates an experience with a safety valve, stating that it worked all right until it lifted about $\frac{3}{16}$ in., when it moved suddenly to a wide-open position.

The action was unquestionably due, first to the fact that the safety-valve area was not adequate and could not, therefore, deliver the excess steam, unless wide open; second, the uniformity of movement was evidently caused by excessive friction in the first part of the valve travel, due to a bent guide pin or scale accumulation.

The area of a safety valve is determined by reference to the mechanics of fluids in motion or upon the results of experiments to ascertain the area necessary for the escape of all the steam the boiler could give. The most usual method is, in the absence of generally recognized rules, to proportion the valve area according to the grate surface, heating surface or horsepower of the boiler. The safety valve is designed on the assumption that the static pressure in the boiler will lift the valve, when this pressure exceeds the exterior pressure or that due to the weight, on the valve. The rise of the valve is sudden whenever there is an excess pressure on the boiler. The height to which a valve will rise cannot be determined theoretically, but the question has been conclusively settled by Burg, of Vienna, after careful and extensive experiments, the results of which are shown in the accompanying table.

POUNDS STEAM PRESSURE								
12	20	35	45	50	60	70	80	90
RISE OF VALVE IN INCHES								
$\frac{1}{50}$	$\frac{1}{30}$	$\frac{1}{21}$	$\frac{1}{15}$	$\frac{1}{12}$	$\frac{1}{10}$	$\frac{1}{8\frac{1}{2}}$	$\frac{1}{7\frac{1}{2}}$	$\frac{1}{6\frac{1}{2}}$

It will be understood that the experiments were conducted with well proportioned safety valves, and under normal conditions.

If a valve be held down until the pressure increases to 2 or 3 lb. more than that for which the valve is weighted then released, as Mr. Hastings has done, it would be impossible to arrive at conclusions, as the valve, having lost its balance, would necessarily fly wide open.

I do not think that there is any ground for apprehen-

sion merely because a valve rises too high, as in any case it only relieves the boiler of excess pressure, and would not cause an increased evaporation greater than a safety valve of lesser lift. The danger lies in the fact that it could not pass all the steam generated. A high lift is due to inadequate valve area.

But there is a decided and immediate danger in holding the valve down until the pressure increases above that for which it is weighted, as, upon releasing it, the valve loses its balance and the effect would be similar to opening the main valve suddenly; a great volume of steam is released, causing water-hammer and, perhaps, an explosion.

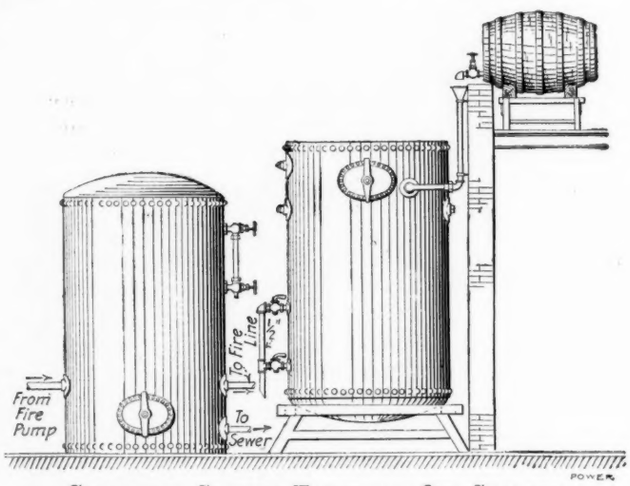
Mr. Hastings' theory, that the high lift of the valve is due to the velocity of the escaping steam impinging upon the valve disk, thereby increasing the pressure is untenable. If it were correct, the valve would be kept open by the outrushing steam until the boilers were totally exhausted. The effect of increased velocity, contrary to Mr. Hastings' theory, is manifest in a decreased lift of the valve; the greater the pressure, or higher the velocity, the less the rise.

VICTOR BONN.

Washington, D. C.

Air Tank Used for Oil Storage

When the plant in which I am employed was installed an air-pressure tank was put in the fire line to insure against shock from the intermittent action of the duplex pump. This pump was controlled by a governor. One



SPRINKLER-SYSTEM TANK FOR OIL STORAGE

day the governor failed to act and the pressure in the tank increased so that it had to be discontinued for that service.

The tank laid around, useless, until several barrels of engine oil arrived, when it was used to store the oil, as the higher temperature of the store room thinned the oil, and the barrels began to leak. The tank was put in the oil room, inverted on a wooden base and painted. The water-glass cocks were removed and stop-cocks put in their place, piped as shown. Plugs were put in the tank outlets. The oil is put in by gravity, this being possible on account of the location of the tank with relation to the outside ground level. A hole is bored in the end of the barrel and a piece of pipe with a valve is screwed in. This is done before the barrel is put on the horses. Then the valve is opened and the oil soon runs out.

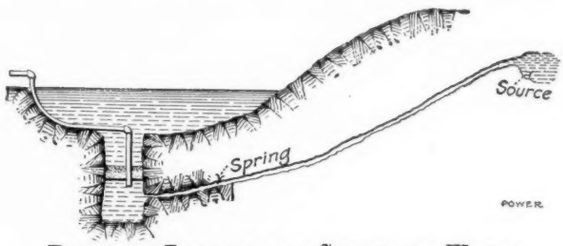
The top cock is used to draw oil as long as it will run from there. When the supply in the tank gets below the top cock it is time to order more.

H. G. GIBSON.

Washington, D. C.

Clear Water from Muddy River*

In the issue of Oct. 28, there is an article with the above heading. I would say that the water in the hole is clear because it is furnished by a spring. The river water does not enter the hole at all, there being a constant upward flow of clear water that keeps out the sedi-



PROBABLE LOCATION OF SOURCE OF WATER

ment. If the cavity could be sealed as shown in the sketch, and the water allowed to escape through the pipe, it would, perhaps, be discharged several feet above the surface of the river.

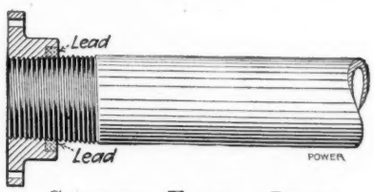
W. B. ODELL.

Birmingham, Ala.

Pipe Joint Soldered at Flanges

We have in our plant a 6-in. steam line supported on saddles at the top of posts about 14 ft. high.

This pipe continues through the yard on these posts for about 300 ft., connecting boilers at either end of the works. We have had, from time to time, leaks in the threads at the ends of lengths where they screw into the



SOLDERED FLANGE JOINT

hub of the flange unions. To take down pipe would be an expensive job, as we would have to cut off pipe and make new threads or substitute new pieces or flanges, as the conditions warranted. To avoid taking down the line we split off flanges with a cape chisel at the bolt holes to inspect the threads. If the thread is poor well within the thread length of the flange, we spread the line open enough, and screw on a new flange with a recess at the back of the hub, into which we pour lead and calk the joint to insure a tight job. The cross-section of one of these flanges illustrates the idea. This may, or may not, be a new idea.

F. R. MAW.

Hancock, Mich.

*"Power," Oct. 28, p. 611; Dec. 2, pp. 976, 977.

INQUIRIES OF GENERAL INTEREST

Coal—What is the difference between hard and soft coal, and why does the former produce less smoke than the latter?

M. S. M.

The main difference between hard and soft coal is that soft coal volatilizes easier, which is the reason why hard coal produces less smoke.

Air-Compressor Power—What amount of power will be required to drive a 10x10-in. compressor making 110 r.p.m. and compressing the air to 40-lb. gage pressure?

Assuming the compressor to be a single-stage compressor in ordinary good condition and of about 80 per cent. mechanical efficiency, the net power required to be delivered to the compressor would be 6½ to 7 hp. An 8- to 10-hp. electric motor should be used to drive it.

Belt Sufficiency—Will a two-ply leather belt 16 in. wide transmit 150 hp. between two 40-in. pulleys on 15-ft. centers at 250 r.p.m.?

C. F.

The belt referred to would not be suitable for more than 106 hp. and would not transmit 150 hp. without giving considerable trouble. For transmitting 150 hp. either the speed of the belt or its width should be increased about 50 per cent.

Valve Lap—In the designing of a slide-valve engine is any difference made in the lap on the two ends on account of the angularity of the connecting-rod?

E. P.

An allowance for angularity of the connecting-rod should be made in fixing the lap on a slide valve, making the lap at one end greater than the other, and for important work such allowance is generally made by careful designers and builders of slide-valve engines.

Forced Draft—Is there not a loss in efficiency when boilers are operated with forced draft? The temperature of the flue gases must necessarily be high, unless it is a water-tube boiler especially baffled for this manner of working.

J. B.

Forced draft is only applied when the natural draft is insufficient for the rate of combustion required or in lieu of natural draft. When properly adapted to the requirements of air for proper combustion the temperature of the escaping gases is no higher than from introduction of the same amount of air by natural draft.

Fan Power Consumption—A 6-ft. fan is driven at 600 r.p.m. from a line shaft running at the same speed, by 24-in. pulleys on both shafts. What effect will it have on the power consumption to substitute two 48-in. pulleys?

L. N.

With either set of pulleys, the fan being driven at the same speed, there would be the same delivery of air and consequently the fan would receive the same number of horsepower. A single advantage in driving with the 48-in. pulleys is that the belt would travel twice as fast as with 24-in. pulleys and the driving tension in the belt would be half as much, which would make about half as much pressure on the hanger boxes and would reduce the shafting friction nearly one-half.

Burning Wood—In substituting wood for coal in a boiler furnace, how much more fuel will be required and what changes will be necessary in the furnace?

H. F.

It is enough to allow 2½ lb. of wood as equal to 1 lb. of coal, if the wood does not contain over 20 to 25 per cent. of moisture. Such wood is usually known as "dry," and whatever greater quantity of moisture may be in the wood will have to be evaporated in place of about an equal evaporation of the boiler. For wood burning there should be fully half more area of grate openings and the boiler should be 50 to 75 per cent. higher above the fire, and the flue-chimney capacity should be about twice as much as for coal. With natural draft and dry wood 20 to 25 lb. of wood should be burned per hour per square foot of grate, and with forced draft 40 to 50 lb.

Water-Meter Correction—What corrections must be made to the readings of a hot-water meter, calibrated to read in pounds at 170 deg. F., but used with water at 100 deg. F.?

J. A. P.

The weight of any unit of volume of water, as a cubic foot, at a temperature of 100 deg. F., is 62.02 lb. and at 170 deg. F. the weight is 60.77 lb. Therefore, readings of a water meter which is calibrated for 170 deg. F., are corrected (for equivalent weight of water) when the water is at 100 deg. F., by multiplying by the fraction

$$\frac{62.02}{60.77}$$ or 1.0206 as a correction factor

Smoke Rings—A locomotive or traction engine after standing idle will often emit rings of smoke for a few revolutions when started. What is the cause?

E. P.

Rings of smoke and steam are formed by a full sharp exhaust which occurs more frequently when the link valve gears are full gear forward or backward. The exhaust and smoke are rolled up against the inside of the stack and, especially when discharged from a straight stack with a contracted outlet, are discharged in rings. A paste-board box filled with smoke will vent rings through a clear round hole in the box by sharply tapping the sides of the box, which shows that the ring is formed by sharp puffs being retarded by the edge of the opening.

Compressing Air with Fan—What is the limit to which air can be compressed with a centrifugal fan? Is it possible to store up air in a tank by means of a fan at a pressure of 4 or 5 lb.?

W. A. M.

The commercial limit of pressure by fan blowers of ordinary construction is about 16 oz. or 1 lb. per sq.in. The action of fan blowers is by free inlet and the accumulation of pressure, being by centrifugal effect resulting from high rotative velocity, the present methods of construction will not admit of practical velocities necessary for higher pressure than 16 oz. as above. It is not practicable, therefore, to store up 4 to 5 lb. per sq.in. pressure with a fan blower. However, belt driven, positive pressure blowers or turbo-compressors can be used for the purpose.

Water in Air Line—We have considerable trouble from water in our compressed-air line. What can be done to avoid it?

F. T.

The trouble results from moisture taken in with the air supply to the compressor. The inlet should be removed from a moist atmosphere such as that of a kitchen or laundry. Any compressed-air line should be run without pockets in the line and should be pitched downward away from the compressor with drip cocks at the lowest points for draining the line when necessary. A remedy for removing moisture from atmospheric air taken into the compressor would be to draw the air through box conduits of wood nearly filled with lime, having the boxes made with loose covers removable for drying out the lime at intervals.

Saving by Feed Heating—What horsepower will be saved if 30,000 lb. of water per hour at 259 deg. F. is returned and mixed with the feed water at 218 deg.?

W. D.

The heat units realized would be

$$259 - 218 = 41 \text{ B.t.u. per lb.}$$

and this, multiplied by the number of pounds, would be

$$30{,}000 \times 41 = 1{,}230{,}000 \text{ B.t.u. per hr.}$$

In converting the feed water into steam and by employing an engine to convert this into useful work, a large percentage of the heat units would be lost. The usual boiler horsepower consisting of the evaporation of 34½ lb. of water from and at 212 deg. F., or equivalent, is equal to the development of 33,479 B.t.u. per hour, and therefore the boiler horsepower which would be saved would be

$$\frac{1{,}230{,}000}{33{,}479} = 36.7 \text{ boiler hp.}$$

ENGINEERS' STUDY COURSE

Trigonometry—VI

Last Lesson's Answers

21. As the cotangent of any angle is equal to its cosine divided by its sine

$$cot\ (A + B) = \frac{cos\ (A + B)}{sin\ (A + B)}$$

Therefore, from equations 13 and 11

$$cot\ (A + B) = \frac{cos\ A\ cos\ B - sin\ A\ sin\ B}{sin\ A\ cos\ B + cos\ A\ sin\ B}$$

Dividing the numerator and denominator of the second term by *sin A sin B*,

$$cot\ (A + B) = \frac{\frac{cos\ A\ cos\ B}{sin\ A\ sin\ B} - \frac{sin\ A\ sin\ B}{sin\ A\ sin\ B}}{\frac{sin\ A\ cos\ B}{sin\ A\ sin\ B} + \frac{cos\ A\ sin\ B}{sin\ A\ sin\ B}}$$

Canceling and substituting the cotangent for the cosine divided by the sine,

$$cot\ (A + B) = \frac{cot\ A\ cot\ B - 1}{cot\ B + cot\ A} \qquad (17)$$

22. As

$$cot\ (A - B) = \frac{cos\ (A - B)}{sin\ (A - B)}$$

from equations 14 an 12

$$cot\ (A - B) = \frac{sin\ A\ sin\ B + cos\ A\ cos\ B}{sin\ A\ cos\ B - cos\ A\ sin\ B}$$

Again dividing the numerator and denominator of the second term by *sin A sin B*

$$cot\ (A - B) = \frac{\frac{sin\ A\ sin\ B}{sin\ A\ sin\ B} + \frac{cos\ A\ cos\ B}{sin\ A\ sin\ B}}{\frac{sin\ A\ cos\ B}{sin\ A\ sin\ B} - \frac{cos\ A\ sin\ B}{sin\ A\ sin\ B}}$$

Canceling and substituting the cotangent for the cosine divided by the sine,

$$cot\ (A - B) = \frac{1 + cot\ A\ cot\ B}{cot\ B - cot\ A} \qquad (18)$$

23. From equation 15 (last lesson)

$$tan\ 75° = \frac{tan\ 30° + tan\ 45°}{1 - tan\ 30°\ tan\ 45°}$$

Given $tan\ 30° = \frac{1}{\sqrt{3}}$ and $cot\ 45° = 1$. The tangent and cotangent being reciprocals $tan\ 45° = 1$ also. Now substituting

$$tan\ 75° = \frac{\frac{1}{\sqrt{3}} + 1}{1 - \frac{1}{\sqrt{3}} \times 1} = \frac{\frac{1 + \sqrt{3}}{\sqrt{3}}}{\frac{\sqrt{3} - 1}{\sqrt{3}}} = \frac{1 + \sqrt{3}}{\sqrt{3} - 1} = 3.7321$$

which agrees with the value given in the table in Lesson II.

24. From equation 18

$$cot\ 15° = \frac{1 + cot\ 45°\ cot\ 30°}{cot\ 30° - cot\ 45°}$$

Given $cot\ 45° = 1$ and $tan\ 30° = \frac{1}{\sqrt{3}}$. Then $cot\ 30° = \sqrt{3}$. Substituting

$$cot\ 15° = \frac{1 + 1 \times \sqrt{3}}{\sqrt{3} - 1} = \frac{1 + \sqrt{3}}{\sqrt{3} - 1} = 3.7321$$

which also agrees with the table and incidentally proves (as it should) that the tangent of an angle is equal to the cotangent of its complement, for $75° + 15° = 90°$.

25. Required an expression for $tan\ (A + B) - tan\ (A - B)$. Combining equations 15 and 16

$$tan\ (A + B) - tan\ (A - B) = \frac{tan\ A + tan\ B}{1 - tan\ A\ tan\ B} - \frac{tan\ A - tan\ B}{1 + tan\ A\ tan\ B}$$

Reduced to a common denominator the second term becomes

$$= \frac{\left((tan\ A + tan\ B)(1 + tan\ A\ tan\ B) - (tan\ A - tan\ B)\right)}{(1 - tan\ A\ tan\ B)(1 + tan\ A\ tan\ B)}$$

which further reduces so that

$$tan\ (A + B) - tan\ (A - B) = \frac{2\ tan\ B + 2\ tan^2\ A\ tan\ B}{1 - tan^2\ A\ tan^2\ B}$$

Dividing the numerator and the denominator of the second term by *tan A tan B*, and substituting the cotangent for the reciprocal of the tangent

$$tan\ (A + B) - tan\ (A - B) = \frac{2\ (cot\ A + tan\ A)}{cot\ A\ cot\ B - tan\ A\ tan\ B}$$

Functions of the Sum and Difference of Angles Concluded

On account of the importance of the equations derived in this and the two preceding lessons and hence more or less separated, they are here recapitulated where they may be more easily referred to when subsequently needed.

$$sin\ (A + B) = sin\ A\ cos\ B + cos\ A\ sin\ B \qquad (11)$$

$$sin\ (A - B) = sin\ A\ cos\ B - cos\ A\ sin\ B \qquad (12)$$

$$cos\ (A + B) = cos\ A\ cos\ B - sin\ A\ sin\ B \qquad (13)$$

$$cos\ (A - B) = cos\ A\ cos\ B + sin\ A\ sin\ B \qquad (14)$$

$$tan\ (A + B) = \frac{tan\ A + tan\ B}{1 - tan\ A\ tan\ B} \qquad (15)$$

$$tan\ (A - B) = \frac{tan\ A - tan\ B}{1 + tan\ A\ tan\ B} \qquad (16)$$

$$cot\ (A + B) = \frac{cot\ A\ cot\ B - 1}{cot\ B + cot\ A} \qquad (17)$$

$$cot\ (A - B) = \frac{cot\ A\ cot\ B + 1}{cot\ B - cot\ A} \qquad (18)$$

Functions of Double and Half Angles

From the equations just given may be easily deduced the functions of angles which are of double or half the number of degrees of any given angle. The functions of

all double angles are found directly by making angles A and B equal. Then equations 11, 13, 15 and 17 become, respectively

$$\sin 2A = 2 \sin A \cos A \quad (19)$$

$$\cos 2A = \cos^2 A - \sin^2 A \quad (20)$$

(also equal to $2\cos^2 A - 1$, or $1 - 2\sin^2 A$, by equation 1, Lesson III),

$$\tan 2A = \frac{2 \tan A}{1 - \tan^2 A} \quad (21)$$

$$\cot 2A = \frac{\cot^2 A - 1}{2 \cot A} \quad (22)$$

From equation 20 (one of its alternative forms)

$$2 \sin^2 A = 1 - \cos 2A$$

Dividing by 2 and extracting the square root

$$\sin A = \pm \sqrt{\tfrac{1}{2}(1 - \cos 2A)}$$

Since A is any angle one-half of it ($\frac{1}{2}A$) may be substituted for it, when the last equation becomes

$$\sin \tfrac{1}{2}A = \pm \sqrt{\tfrac{1}{2}(1 - \cos A)} \quad (23)$$

(The sign $\pm$, *plus or minus,* always goes before an expression for square root, as either a product of *minus* and *minus* or *plus* and *plus* will give a plus product, but for any one of these functions having the sign $\pm$ before it, the function is $+$ if the angle A is less than 180°).

Also from equation 20

$$2\cos^2 A = 1 + \cos 2A$$

and similarly as before

$$\cos \tfrac{1}{2}A = \pm \sqrt{\tfrac{1}{2}(1 + \cos A)} \quad (24)$$

The tangent being equal to the sine divided by the cosine

$$\tan \tfrac{1}{2}A = \frac{\sin \frac{1}{2}A}{\cos \frac{1}{2}A}$$

and, expressions having just been found for these,

$$\tan \tfrac{1}{2}A = \pm \frac{\sqrt{\frac{1}{2}(1 - \cos A)}}{\sqrt{\frac{1}{2}(1 + \cos A)}}$$

which reduces to

$$\tan \tfrac{1}{2}A = \pm \sqrt{\frac{1 - \cos A}{1 + \cos A}} \quad (25)$$

and, the cotangent being the reciprocal of the tangent,

$$\cot \tfrac{1}{2}A = \pm \sqrt{\frac{1 + \cos A}{1 - \cos A}} \quad (26)$$

Study Questions

26. Given $\sin 45° = \frac{1}{2}\sqrt{2}$ find the sine, cosine, tangent and cotangent of 22 deg. 30 min.

27. Deduce an expression for the sine of the sum of three angles.

28. Deduce an expression for $\sec (A + B)$.

29. Deduce an expression for $\sin 3A$.

30. Given $\tan 30° = \frac{1}{\sqrt{3}}$ find the sine, cosine, tangent and cotangent of 60 deg.

❖

Oswego Factories Plan Big Power Merger—Plans for concentration of all water-power interests along the Oswego River are completed, according to an announcement made by George Coffing Warner, of New York, president of the Fulton Light, Heat & Power Co., Fulton, N. Y. The plan provides for supplying electrical current to operate factories which now are depending upon waterwheels for power. The project will be capitalized for more than $2,500,000.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

A young woman has asked New York police headquarters for a fireman's license; says she's been firing and oiling for three years. This generation is sure producing some mighty manly young women. Perhaps the prevailing styles in overalls will undergo a decided change. Haberdashers, please answer.

❖

"Save the man of 40! He is more important to the community than the baby," says a high forehead. Whatcha mean, the babies can't holler? And where are we going to get those 40-year-olds 40 years from now if we frown down the infant industry? It can't be done!

❖

This eugenics thing has been given a jolt by Prof. Coulter, of Chicago University. "Innate delicacy and common sense are causing a revulsion of feeling touching eugenics." The eugenists might turn their attention to poultry, or horses, or dogs, with good results, but humans!

❖

There's nothing slow about Philadelphia when it can have an electric-cable explosion! Wish we could get more particulars. Was it due to a short circuit between high-voltage ammonia pipes and low-voltage superheated steam mains? Or perhaps some brute jabbed it with a needle.

❖

Speaking of the evils of smoke pollution, it was recently said that "the functional efficiency of the visual naso-pharyngeal, pulmonary, gastro-intestinal and neural mechanisms may be disabled by constant irritation by smoke particles." Yes, and even the eyes, nose, lungs, stomach and nerves are sometimes equally affected.

❖

Gol' darn if those Boston Power Show boosters aren't at it as if the big noise came off in January instead of Apr. 27! Wish we could go. We'd dig down to Mrs. Atkinson's first thing for a plate of beans and brown bread, and then we'd sneak up the alley to the "Bell in Hand" and have—well, we'd not get it in a plate. But mebbe these oldtime hang-outs are now ancient history? Then we'd make tracks for the old Revere House and hunt up a Commercial Engineer. Feller, you can't stump your Uncle Billy?

❖

Mister Fra Hubbard (no relation of old Mother Hubbard) has recently been heaping praise upon the heads of Dr. Steinmetz, Samuel Insull and Henry Doherty. The Fra is some heaper when it comes to praise, but these three men deserve it, which is not always the case.

❖

"An accident happened to a steamer shortly after leaving Habana," says a Cuban correspondent. "The next day a local paper had the following account of the occurrence:

"'Yesterday the steamer "X" left port en route for Santander and Corunia but returned just at nightfall owing to an accident to her machinery. The chief engineer informed our representative that the main steam valve had slipped and bent the low-pressure cylinder.'"

❖

My word, old top, if you feel you have a liver, when readin' the awf'ly dry reports of meetin's in the States, you'll jolly well be refreshed by an account of a Local Government Board meetin' at home:

"The profits of the gasworks were nearly £13,000," says Mr. Ekin.

"Fiddlesticks!" says Mr. Smith, who's a sassy, not to say profane man.

Then a knowin' Johnny says the illumination power won't reduce below 15 candles.

Then Smithie says, right out, you know: "What is to be the calorific power?"

"In what?" asks old chap Ekin.

"In Board of Trade units," says Smithie. And then the whole meetin' began lawfing and chawfing— and a few tittered, Absolutely!

And then Ekin goes off his chump and says: "Board of Trade units in a gas plant! Rubbish! Sit down!"

And then—well, that's all, dear boy, but isn't it a bit of home, eh what? Quite so!

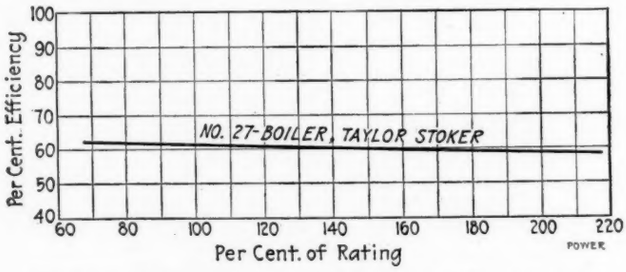
Further Operation of Large Delray Boilers†

By J. W. Parker

SYNOPSIS—During two years' operation of seven of these boilers only two tubes have had to be replaced and the boilers have been ready for service 95 per cent. of the time, or 100 per cent. of the time during peak-load periods. As high as 11,000 kw. has been carried on a single boiler for over an hour.

At the December, 1911, meeting of the society, Dr. D. S. Jacobus presented a paper* giving the results of the first performance tests on the 2365-hp. Stirling boilers at the Delray generating plant of the Detroit Edison Co. At the time of his tests three of these boilers were in service, one having been run about 18 months and the others nine months. Since that time six more of the type have been installed.

The causes which might take boilers out of commission at times when they are needed for service are being eliminated. The boiler itself need be no hazard. Fittings and flanged joints, if properly watched and followed up,



Overall Efficiency of Boiler and Furnace at Different Ratings

do not cause shutdowns. The same is true of the tubes, which are seamless. From Oct. 15, 1912, to Nov. 1, 1913, there have been but two tubes replaced in seven boilers whose average age is two years. One front tube was taken out after the discovery of a small bag next to the fire, which was found during a periodical inspection. The other was spoiled by a mishandled turbine-tube cleaner.

The plant is using about 8 per cent. of makeup water, and a sulphate scale about $\frac{1}{16}$ in. thick forms in the hot front tubes. These front surfaces are worked exceedingly hard and scale of even $\frac{1}{16}$ in. thickness may make trouble. A soft piece of mud, lodging on top of the hard scale is likely to cause a small bag. This trouble can occur only in the lower bends of the first row of tubes, where loose dirt sometimes lodges. Tube trouble will be practically eliminated by the use of pure water. The makeup water is now river water, treated with enough barium hydrate to neutralize the sulphate content. The percentage of makeup can be reduced to between 2 and 3 per cent. by avoiding the necessity of blowing down boilers. It is seriously contemplated to use distilled water for makeup. There seems to be a lack of evidence that distilled water is of itself corrosive, but to safeguard against any possible boiler corrosion, enough soft scale-forming material would be introduced into the feed water to cover the heating surface with a thin protecting scale.

†From paper read at annual meeting of the A. S. M. E.
*See "Power," Dec. 5, 1911.

Stokers

Repairs ordinarily made on the stokers are the replacement of tuyeres, dump plates, etc., which have burned out. There have been cases of sudden stoker breakdown, sometimes occasioned by the introduction of chunks of iron or wood into the stoker rams, along with the coal. Also, there have occurred once or twice, serious burnouts of tuyeres and other grate surfaces extending over an area of 5 or 6 sq.ft. In these instances the fire was banked on the side of the furnace where the trouble existed and the other half of the furnace operated to get half capacity from the boiler.

Reliability

To sum up, our experience has been this: The boilers were ready for service 95 per cent. of the time considered; they were ready 98 per cent. of the five full-load days of the week; and ready for service 100 per cent. of the time during the peak-load periods. It is to be assumed that the boilers must be down for ten days or two weeks at nine- or ten-month intervals for cleaning and a general overhauling of stokers and brickwork.

The Detroit Edison Co. is now building a power plant to contain six 20,000-kw. turbines served by 12 of these 2365-hp. boilers, which is two boilers to one turbine, with no spares, or 10,000 kw. per boiler. Although the chances of losing the capacity of any boiler by a forced shutdown are remote, they have, nevertheless, been considered. At normal full load on a given turbine unit, the two boilers will operate at approximately 191 per cent. of rating based on 10 sq.ft. of heating surface per boiler horsepower. If with six boilers running at this rating, one boiler should go completely out of commission the other five would have to carry the entire load of 60,000 kw. and thus operate at 235 per cent. of rating, which is perfectly possible. As a matter of fact, the settings and auxiliaries are being designed to allow of continuous operation at 255 per cent. of rating, which would enable three boilers to take the full load of four, that is, 40,000 kw. Very recently, one of the Delray boilers was isolated from the rest of the plant with a 15,000 kw., seven-stage Curtis vertical turbine, and over 11,000 kw. was carried for an hour without difficulty.

The overall boiler and furnace efficiency of one of the Taylor stoker-fired units is shown by Fig. 1. The curve has a gradual slope from 80 per cent. efficiency at 93 per cent. of rating, to 76 per cent. efficiency at 214 per cent. of rating. It is economical, therefore, to run as many boilers as possible at about 90 per cent. of rating when the plant load is light, and then carry the peak by increasing the rating on the boilers. This is our present practice, which is very convenient in summer when provision must be made for a sudden peak due to a thunder storm.

Fire-Room Operation

The plan is for one man to operate two stokers, and in addition, to have a head fireman in charge of from six to eight units, whose duty it is to oversee all the fires, and give assistance to any fireman who needs help. On the gage board are mounted steam gages showing the

pressure at the superheater inlet and outlet and draft gages showing the air pressure under the fire, draft at the damper, and draft at the top of the combustion chamber. There is also on this board the record dial of a CO_2 meter. The meter itself is mounted on a gallery 15 ft. above the boiler-room floor in a position central to four boilers. Four samples of gas are drawn from one furnace, automatically mixed, and the resulting analysis is recorded where the fireman can watch it.

A water tender stationed on a gallery at the top-drum level feeds the boilers, but the fireman does everything else in the way of operation. The dampers are shifted at the control point, and the throttles of the blower turbines are extended through the floor near the gage board. The stokers are motor driven and one of the controllers is located on a steel column 6 ft. away from the gage board; the other could have been brought around also, but it was thought unnecessary, since a man must walk around to the stoker on the distant side to watch it and to study his fire. The control point of the opposite boiler is located just across the aisle from the first.

The whole idea is to employ the most expert firemen and give each man control of the burning of a very large amount of coal. It is economical to employ a fine type of man and pay him an expert's pay. The present first-class fireman's pay is 40c. an hour and he is well treated as to vacation and sick leave. These men are given the benefit of whatever boiler testing is done, and a force of firemen is being built up that can obtain remarkable results with their fires. At the same time the unit cost of firing is unusually low.

At the end of each firing aisle is mounted a large pilot steam gage. The dial is graduated in divisions of 1½ in. on its circumference but with no figures, and each scale division registers 1 lb. per sq.in. It is found and marked at just what point on this sensitive gage the boiler safety valves will lift and the steam pressure is carried accordingly. On the same gage board with the pilot gage are a clock and the dial of a load indicator, operated from the switchboard gallery, indicating the load on the entire plant in kilowatts. In handling his fires, the fireman is guided first by steam requirements, as shown by the pilot gage, and a steam-flow meter. The air pressure under the fire and the stoker speed are controlled by hand.

The stokers are driven by direct-current interpole motors having a speed control by field resistance of four to one, and with 18 running points on the controllers. Indicating dial tachometers are being installed on the stoker shafts, so that the stoker speed for a given load may be watched carefully.

As to furnace conditions, the firemen must judge by the CO_2 recorder, by the amount of air pressure necessary for any given boiler load, and also by the color of the gases as they pass over the first baffle and enter the top of the superheater pass. A reflecting observation device for this is at present being tried out, which allows the fireman to look into the boiler pass from a position near his gage board.

Automatic vs. Hand Control

As for feeding the boiler, a skillful water tender learns not to touch the feed valve except at rare intervals and when the load on the plant becomes steady, the steam flow is continuous also. One automatic feed-water regulator was tried out, but was not a success, due largely to a peculiarity of this type of boiler. On account of the rapid circulation, the water in the top middle drum stands at times 2 ft. or more above that in the two outside drums, although the three are connected with water-circulating tubes as well as by steam circulators and the main boiler tubes. The water columns are piped to the center drum, there being often no indication of water whatever in the outside drums. Under these conditions it is easy for a feed-water regulator, automatically attempting to hold a constant level in the center drum, to get into difficulties whenever the demand for steam varies sharply. When the steam demand decreases slightly, the water level may fall possibly an inch, being very sensitive. If the regulator immediately opens and starts feeding more heavily, the circulation will be still further decreased, and then the water level will fall lower and the regulator feed still more heavily. The steam output of the boiler will decrease rapidly with this, until the regulator begins to close again. The steam output will now begin to increase and the water level rise also and presently close the regulator entirely; a typical "hunting" action is thus set up.

It is not desirable to substitute an automatic air and stoker control if a better CO_2 chart cannot be shown thereby. The danger is that the fireman will rely on the automatic device, rather than study conditions and control his fire intelligently. With the present hand control, excellent furnace conditions are being obtained and held. Observation of the furnace gases, as they enter the superheater pass from the top of the combustion chamber, shows that the combustion of volatile gases is entirely complete and that the operation is consequently smokeless. At the same time, the CO_2 charts show remarkably good results, 15 per cent. of CO_2 being very common, the average being about 13.5 to 14 per cent.

Good conditions are most often disturbed by the periodic dumping of the ash and refuse from the stokers. There is now being tried out a continuous dumping device, a revolving grate, which bids to be very successful.

Setting Repairs

The settings of the boilers, fired with Taylor stokers, consist simply of four walls without arches or bridge-walls. The only brick repairs necessary thus far have been the annual rebuilding of part of both front walls extending from the stoker to the mud drum of the boilers. The end walls give no trouble when carefully bonded to the facebrick of the setting.

The most educative experience with brickwork has been had with the Roney stoker settings and their furnace arches. At first we had sprung arches under each mud drum with a central wall intersecting the bridge-wall at right angles. These pulled themselves out of shape, however, and we now use a single continuous "flat arch" under the mud drum, built of firebrick shapes hung from cast-iron rail beams. For these shapes a special brick had to be made of an exceedingly loose texture obtained by mixing sawdust with the clay before molding. Upon burning in the kiln, this sawdust burned out, leaving the brick very porous.

Limitations of Boilers

As at present installed, these boilers present certain limitations to being driven at much higher rates than al-

ready obtained. First, in burning West Virginia, long-flaming bituminous coal, it is probable that at about 275 per cent. of rating the flames will reach the top of the combustion chamber, which is 28 ft. high. As soon as uncombined combustible gases get over into the superheater pass, the overall efficiency of the unit will drop, and smoke will begin.

If the boilers in future installations are set much higher another difficulty will arise, although this is not so serious. Either more stack draft must be provided, or a pressure will be developed at the top of the combustion chamber, and the brick setting at this point must be built gas-tight.

Another limitation is the drop in pressure through the superheater, the automatic check valves and the stop valve. At 210 per cent. of rating on one boiler, the drop in pressure through the superheater is 21 lb., which includes the pressure drop through the automatic check valves, but not that through the main stop valve. At 255 per cent. of rating it would be considerably more. Since the pressure on the steam mains must remain constant, a pressure must be carried on the saturated steam drums of the boiler of 21 lb. more than at the superheater outlet, when running at 210 per cent. of rating.

Effect on Tubes

As for the effect on the front tubes of the type-W boiler, of running at very high rates of evaporation, it has been found that the tubes have shown no evidence of injury due to the hard driving. One thing is certain, however, and that is these tubes must be kept clean. As previously stated, scale which ordinarily would give no trouble, has possibilities for mischief under the conditions of harder driving.

Cost of Steam and Gas Power Equipment

By A. A. Potter*

SYNOPSIS—A table of equations deduced from manufacturers' quotations for a large list of power-plant equipment. The prices are all f.o.b. at the factory.

As a rule, selling prices of machinery are carefully guarded by manufacturers. The author, finding it necessary to use such prices very often for preliminary estimates, sent out letters to several hundred manufacturers, asking for net selling prices. The majority of the companies responded with confidential price lists. These lists were carefully tabulated and plotted, and it is hoped that the equations deduced from these plots may prove of value to others. The complete data, including tables and plots, will probably be published as a bulletin of the Engineering Experiment Station of the Kansas State Agricultural College.

The equations in the table are arranged in the alphabetical order of the machinery for which prices are given. The prices are f.o.b. at the factory, and do not include erection costs. There are many varying factors entering into erection costs, so that it is impossible to give general estimates which may be regarded as accurate. Some manufacturers quoted the following erection costs for high-speed engines:

Size of Engine, Hp.	Approximate Erection Cost in Dollars
75	125 to 150
100	150 to 200
150	200 to 300
300	300 to 400
450	400 to 450
600	400 to 600

Prof. C. H. Benjamin, in his book on the "Steam Engine," gives the following formulas for the costs of engine settings:

1. Setting for high-speed engines. Cost in dollars = 50 + 0.75 (horsepower).
2. Setting for low-speed engines. Cost in dollars = 500 + 1.3 (horsepower).

Settings for water-tube boilers vary from $400 for a 100-hp. boiler to about $650 for a 600-hp. boiler.

In the case of internal-combustion engines, the erection will vary from 7 to 15 per cent. of the total cost of the engines. The erection cost of large engines may be as low as 3 per cent. of the cost of the engine.

Difficulty was experienced in developing an equation for the cost of stokers which would be applicable over a wide range, as the size of stokers for the same boiler horsepower varies greatly with the fuel to be handled, the available draft, and other conditions. Also, in the case of underfeed stokers which include a forced-draft equipment, the cost depends on the number of boilers. Thus a quotation of $1055 was given by one concern for an underfeed stoker to be used in connection with one 125-hp. fire-tube boiler; $1793 for an equipment suitable for two boilers of the same size, and only $6300 in the case of eight boilers. A manufacturer of front-feed stokers quotes $975 for a stoker equipment for one boiler, and $1680 for an equipment for two boilers. The equations apply very nearly to equipments of four stokers, or to a lesser number.

The prices in the case of condensers are based on a cooling-water temperature of 60 deg. F., the equations are developed with reference to the pounds of steam condensed per hour.

The prices for internal-combustion engines include standard equipment. This in the case of gasoline engines consists of a battery, gasoline tank, water tank or circulating pump, muffler, and all pipes and fittings needed for the ordinary installation. With oil engines, oil pumps, heating lamps and mufflers are supplied. Also with an internal-combustion engine above 25 hp. self-starting devices are usually included.

The prices on oil engines include such internal-combustion engines as are suitable for burning very heavy oils. The cost of oil engines suitable for oils of 39 deg. Bé., or lighter, does not differ more than a few per cent. from that for gasoline engines.

The capacity of producers is given in horsepower, this being based on a producer efficiency of 75 to 80 per cent., and 10,000 to 11,000 B.t.u. per brake horsepower per hour, as the term producer horsepower has no definite meaning unless it is based on the B.t.u. consumption of the internal-combustion engine to which the gas is supplied. Some manufacturers of gas producers have aban-

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TABLE OF COSTS OF STEAM AND GAS POWER-PLANT EQUIPMENT

Name of Apparatus	Type	Capacity	Equation of Cost in Dollars
Air compressors	Single cylinder, belt-driven	Up to 4000 cu.ft. per min.	52 + 1.95 × cu.ft.
	Duplex, belt-driven	Up to 850 cu.ft. per min.	316 + 1.675 × cu.ft.
	Compound, belt-driven	Up to 550 cu.ft. per min.	3.1 × cu.ft.
	Single cylinder, steam-driven	Up to 350 cu.ft. per min.	231 + 2.32 × cu.ft.
	Duplex, steam-driven	Up to 600 cu.ft. per min.	460 + 2.55 × cu.ft.
	Compound, steam-driven	Up to 500 cu.ft. per min.	71.25 + 4.025 × cu.ft.
Boilers, steam	Vertical, fire-tube	Under 20 hp.	49.2 + 6.66 × hp.
	Submerged tubes, 100 lb. per sq.in. or less	20 to 50 hp.	116.4 + 3.35 × hp.
	Full length tubes; 100 lb. per sq.in. or less	Up to 50 hp.	51.5 + 3.62 × hp.
	Horizontal, fire-tube cylindrical, multi-tubular, 100 lb. per sq.in. or less	Up to 200 hp.	64 + 4.14 × hp.
		Up to 100 hp.	5.8 × hp. — 20
		100 hp. to 225 hp.	211 + 3.35 × hp.
	Portable locomotive	Up to 100 hp.	121 + 5.68 × hp.
	Vertical, water-tube, pressures over 125 lb. per sq.in.	100 to 500 hp.	912 + 6.28 × hp.
	Horizontal, water-tube, pressures over 125 lb. per sq.in.	100 to 600 hp.	149 + 8.24 × hp.
Condensers	Barometric (28-in. vacuum)	Up to 30,000 lb. of steam per hr.	1055 + 0.112 × (lb. steam cond.)
	Jet condensers	Up to 30,000 lb. of steam per hour; 28-in. vacuum	1176+0.1138 × (lb. steam cond.)
		26-in. vacuum	116 + 0.0591 × (lb. steam cond.)
	Surface condensers	Up to 35,000 lb. of steam per hr.; 28-in. vacuum	1630+ 0.2038 × (lb. steam cond.)
		Up to 30,000 lb. of steam per hr.; 26-in. vacuum	413 + 0.1015 × (lb. steam cond.)
Economizers	Number of tubes 32 to 10,000, heating surface per tube = 12 to 13 sq.ft.	Capacity in lb. of water per tube = 60 to 70	
		Economizer alone	$8 to $10 per tube
		Economizer erected	$12 to $15 per tube
Engines, internal combustion	Gas engines	Up to 300 hp.	33.6 × hp. — 115
	Gasoline engines, hit-and-miss governor	Up to 100 hp.	141 + 24.8 × hp.
	Gasoline engines, throttling governor	Up to 75 hp.	309 + 36.1 × hp.
	Oil engines	Up to 400 hp.	63.8 × hp. — 316
	Producer gas engines, American mfg.	Up to 300 hp.	400 + 33.5 × hp.
Engines, steam	Simple, Throttling governor, slide valve, vertical	Up to 70 hp.	63.5 + 17.5 × hp.
	Throttling governor, slide valve, horizontal, Upper limit in cost	Up to 70 hp.	107 + 13.3 × hp.
	Lower limit in cost	Up to 200 hp.	80 + 5.81 × hp.
	Simple, Flywheel governor, piston or balanced slide valve, horizontal	Up to 500 hp.	386 + 6.69 × hp.
	Automatic cut-off, single valve, vertical	Up to 30 hp.	164 + 9.53 × hp.
		30 to 150 hp.	372.5 + 9.55 × hp.
	Flywheel governor, Corliss non-releasing valve, horizontal	Up to 600 hp.	1100 + 8.94 × hp.
	Corliss governor and valves, horizontal	Up to 400 hp.	1040 + 8.45 × hp.
		300 to 900 hp.	730 + 9.1 × hp.
	Flywheel governor, multiple flat valves	Up to 400 hp.	685 + 7.69 × hp.
	Cross compound, Ball governor, single-valve, horizontal	Up to 330 hp.	735 + 8.0 × hp.
	Ball governor, single-valve, vertical	Up to 200 hp.	750 + 10.4 × hp.
	Flywheel governor, multiported valves, horizontal	Up to 600 hp.	1100 + 9.62 × hp.
	Shaft governor, Corliss non-releasing valves, horizontal	Up to 600 hp.	2015 + 9.74 × hp.
	Tandem compound, Flywheel governor and slide valves, horizontal	Up to 400 hp.	559 + 8.83 × hp.
	Flywheel governor and slide valves, vertical	Up to 140 hp.	610 + 12.7 × hp.
	Flywheel governor, Corliss non-releasing valves, horizontal	Up to 300 hp.	1295 + 10.79 × hp.
	Flywheel governor, multiple slide valves	Up to 500 hp.	1010 + 7.65 × hp.
Fans and blowers	Sizes 70 to 140 in.		6.25 × (size in inches).
Feed-water heaters	Open	Up to 1500 boiler hp.	114.5 + 0.3787 × hp.
		1500 to 3000 boiler hp.	326 + 0.237 × hp.
	Closed	Up to 3000 boiler hp.	40 + 0.72 × hp.
Generators, electric	Direct current (voltage 110-250), belted	Up to 7 kw. (1400 to 2300 r.p.m.)	21.1 + 28.5 × kw.
		10 kw. to 300 kw. (600 to 1400 r.p.m.)	10 × (kw.) — 9
	Direct-connected	Up to 300 kw. (100 to 350 r.p.m.)	313.3 + 10.93 × kw.
		300 to 1000 kw. (moderate speed)	12.08 × (kw.) — 383
	Alternating-current, belted	Up to 300 kv.a. (600 to 1800 r.p.m.)	81 + 9.723 × kv.a.
	Direct-connected	Up to 300 kv.a. (200 to 300 r.p.m.)	375 + 7.477 × kv.a.
		250 to 2500 kv.a. (100 to 250 r.p.m.)	2413 + 4.69 × kv.a.
Motors, electric	Direct-current, belted; small sizes	Up to 1.5 hp. (1400 to 2500 r.p.m.)	18.53 + 42.37 × hp.
		1.5 to 30 hp. (1000 to 1800 r.p.m.)	53.3 + 12.4 × hp.
		30 to 100 hp.—Upper limit (500 to 800 r.p.m.)	191.7 + 10.94 × hp.
		Lower limit—(800 to 1000 r.p.m.)	213 + 8.264 × hp.
	Variable speed	Up to 10 hp.—Upper limit	64.1 + 36.786 × hp.
		Lower limit	69.2 + 10.56 × hp.
	Alternating current: Single-phase (110-220 volts)	Up to 25 hp. (1200 to 1800 r.p.m.)	25 + 11.75 × hp.
	Belted; polyphase induction	Up to 130 hp. (1200 to 1800 r.p.m.)	116 + 4.72 × hp.
	Variable speed	Up to 25 hp.	60.7 + 7.15 × hp.
		35 to 60 hp.	157.6 + 3.573 × hp.
Producers, gas	Suction	Up to 300 hp.	252 + 14.2 × hp.
	Pressure	Up to 300 hp.	860 + 15.15 × hp.
Producer plants, gas	Suction	Up to 200 hp.	570 + 46.5 × hp.
Pumps	Boiler feed Single-cylinder, piston pattern	Up to 6000 gal. per hr.	17.8 + 0.2586 × (gal. per hr.)
		6000 to 27,000 gal. per hr.	106.8 + 0.011045 × (gal. per hr.)
	Duplex, piston pattern	Up to 29,000 gal. per hr.	585 + 0.0115 × (gal. per hr.)
	Single-cylinder, outside-packed, plunger pattern	Up to 24,000 gal. per hr.	0.034 × (gal. per hr.)
	Duplex, outside-packed plunger pattern	Up to 49,000 gal. per hr.	0.042125 × (gal. per hr.)
	Centrifugal Horizontal, low-pressure, single-stage	Up to 14,000 gal. per min.	52 + 0.05525 × (gal. per min.)
	Horizontal, high-pressure, single-stage	Up to 5000 gal. per min.	61 + 0.0868 × (gal. per min.)
		5000 to 20,000 gal. per min.	210 + 0.0567 × (gal. per min.)
	Horizontal, high-pressure, multi-stage	Up to 2200 gal. per min.	117 + 0.233 × (gal. per min.)
	Vertical, low-pressure, single-stage	Up to 20,000 gal. per min.	60 + 0.05575 × (gal. per min.)
	Vertical, high-pressure, single-stage	Up to 20,000 gal. per min.	50 + 0.0865 × (gal. per min.)
	Vertical, high-pressure, multi-stage	Up to 1100 gal. per min.	125.7 + 0.27 × (gal. per min.)
	Geared power Single cylinder	Up to 20,000 gal. per hr.	90 + 0.0316 × (gal. per hr.)
	Single-acting, triplex	Up to 83,000 gal. per hr.	56 + 0.03867 × (gal. per hr.)
	Double-acting, triplex	Up to 89,000 gal. per hr.	195 + 0.0148 × (gal. per hr.)
	Rotary force pumps	1200 to 20,000 gal. per hr.	8 + 0.0117 × (gal. per hr.)
	Wet vacuum pumps	Up to 13,000 gal. per hr.	18 + 0.01435 × (gal. per hr.)
		13,000 to 50,000 gal. per hr.	14 + 0.00863 × (gal. per hr.)

TABLE OF COSTS OF STEAM AND GAS POWER-PLANT EQUIPMENT—Continued

Name of Apparatus	Type	Capacity	Equation of Cost in Dollars
Purification plants	Water	1000 to 20,000 gal. per hr.	1000 +0 .2 × (gal. per hr.)
Stokers	Chain-grate	100 to 300 boiler hp.	86 + 4.28 × (hp.)
		300 to 500 boiler hp.	434 + 3.1 × (hp.)
	Front-feed	100 to 660 boiler hp.	312 + 3.015 × (hp.)
	Under-feed	Up to 600 boiler hp.	379 + 2.785 × (hp.)
Superheaters	200 to 750 boiler hp.		
		100 deg. of superheat	165 + 2.578 × (hp.)
		200 deg. of superheat	52 + 3.466 × (hp.)
		300 deg. of superheat	40 + 4.28 × (hp.)
Transformers	Air-cooled	Sizes up to 3000 kv.a.	439 + 1.467 × kv.a.
	Oil-cooled	Sizes up to 30 kv.a.	
		25 cycles	52.9 + 8.1 × kv.a.
		60 cycles	26.2 + 6.25 × kv.a.
		Sizes 30 to 100 kv.a.	
		25 cycles	157 + 4.68 × kv.a.
		60 cycles	119.5 + 3.57 × kv.a.
	Water-cooled	Sizes up to 1000 kv.a.	181 + 1725 × kv.a.
		1000 to 3000 kv.a.	805 + 1099 × kv.a.
Turbines, steam	Reaction type: Turbine and generator	500 to 5000 kw.	3335 + 13.33 × kw.
		5000 to 10,000 kw.	17,500 + 10.5 × kw.
	Impulse type: Turbine alone	Up to 50 hp.	171.5 + 10.7 × hp.
		50 to 400 hp.	10.74 × hp. — 54
	Turbine and generator	Up to 40 kw.	304.2 + 36.78 × kw.
		25 to 350 kw.	30.4 × kw. — 100
		1000 to 10,000 kw.	8106 + 11.34 × kw.

doned the horsepower rating, and rate their producers in pounds of coal, which is the same as the B.t.u. basis.

The prices given for generators and motors apply to standard speeds. Of the many variables which must be taken into consideration in connection with prices on dynamo-electric machinery, speed is the most important, as the amount of copper in a machine (the voltage remaining constant) is determined by the speed for which it is designed.

The prices for transformers are for voltages of 1100 and 2200. The increase in cost for higher voltages, above that for 1100 and 2200 volts is about as follows:

	Per Cent.
6,600 volts	2.5
11,000 volts	7
22,000 volts	18
44,000 volts	40

It is impossible to give the cost of switchboards in the form of an equation, as the requirements are different for each individual plant in the matter of circuits, protective devices, instruments, etc. There is also a great variation in the cost of electrical-measuring instruments of the same capacity.

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Oxyacetylene Boiler Welding*

By Henry Cave†

SYNOPSIS—With particular reference to boiler welding the author gives his views as to why the oxyacetylene process is not more in use and his belief in its possibilities. He then proposes a "Three-License System" as a safeguard against dangerous or unreliable work.

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Very little oxyacetylene welding has been done on tension parts of boilers and other pressure containers. This is particularly true of boilers that come under restrictions imposed by federal, state, civic or insurance regulations. The writer commends this condition, and heartily favors increased restrictions, but believes that they should be based upon principles other than those now in force.

After six years' experience in practical welding with a large number of men on a wide variety of work, and on a large number of tensile and other tests on samples prepared under various conditions, the writer is convinced that welds can be made from the ordinary steel of commerce with approximately the strength and with a fair proportion of the ductility of the original metal, if the work is carried out under certain conditions not difficult to obtain. Therefore, he believes that the development of the oxyacetylene industry is being retarded by the nature of the restrictions imposed. It has been proved repeatedly that welds can be made so strong that the test bar will break outside of the zone of the heat, showing that the weld is at least as strong as the original metal. Many tests have been made in which samples broke in the weld (and in a number of cases outside) with a load varying only by a small percentage from that obtained by pulling samples of the unwelded material, and the welds were ground off to the uniform section.

Even if only one tested weld had shown a strength nearly equal to that of the original metal, it would indicate that it is possible to obtain such a result with the process under the right conditions. These conditions have been found to be:

(1) A torch equipment that can be adjusted to give a uniform flame under all conditions of temperature, burning the acetylene with the least proportion of oxygen that will give the clear outline of the high-temperature flame (interior cone). If any more is supplied, the additional oxygen must pass through the high-temperature flame in its uncombined state, and, coming in contact with the molten metal, produce practically instantaneous oxidation, which cannot help but affect the strength. As an oxidized weld will be brittle and may be weak, consideration should be given to the mixture produced by the torch. Obviously impurities in either of the gases may produce weak welds, and this feature should also be considered.

Other considerations are: The effects that the heat reflected back on the torch head may have on the mixture, which is dependent upon the way the gases are mixed together, the expansion and contraction of the orifices produced by the varying temperatures, which necessarily

*Abstract of a paper entitled "The Oxy-Acetylene Process as Applied to Steel Welds in Tension," presented before the New York section of the American Institute of Steam Boiler Inspectors, Nov. 28, 1913.

†President of the Case Welding Co., formerly, the Autogenous Welding Equipment Co., Springfield, Mass.

vary the velocity of the propelling fluid, and the uniformity of action of the reducing valves and regulators controlling the pressure of both the oxygen and the acetylene.

(2) The second consideration is that of the operation of the torch. Unfortunately, using the torch appears to require little skill. The novice thinks the movements of the torch are solely to spread the heat, whereas they are also to spread the metal. The ideal weld in steel is made by spreading each drop as thin as possible over a large area, being sure that the metal over which it is spread is hot enough for the two to flow together and that the edges of the drop, instead of being rounded like a drop of water on a greasy plate, will spread out as if the drop had been placed on a piece of blotting paper. It is also necessary to blow away the particles or films of oxide, which are readily distinguishable as they are much brighter than the metal.

The adjustment and skill necessary to carry this out can be obtained only by considerable experience with the torch. Other metals require other treatments, which also can only be learned by experience.

(3) The third consideration is the material, fluxes and methods used. If the adding material (melt bar or welding wire) used is of a lower tensile strength than the metal being welded, and variations in other properties occur, and the material is welded in and left in its original condition, the weld cannot be as strong as the original metal. If the test of the weld shows a higher tensile strength than the test of the adding material a change has taken place in the material, and this generally results detrimentally to some other property, and even though the strength is increased it is questionable whether this is desirable.

In taking the strength of a welded sample that has been tested, the comparative strength of the weld, if the fracture occurs at that point, should be taken as being proportional to the strength of the adding material and not to the strength of the original bar. Even though originally the same, a true comparison may not be obtained as the original material may change in strength after being heated. The strength may be lowered or raised by heat treatment. This depends upon the history of the material as to fatigue, method of manufacture (such as cold or hot rolling) and heat treatment.

Steel takes its structure from the highest temperature to which it has been raised. This structure varies on the rising temperature only. Unfortunately, the structure produced by the molten temperature is very coarse, which, though it may mean a greater strength, will mean a lower ductility and increased brittleness. This has to be considered in welding, but the welding is not responsible for it. The metal, whether welded or not, if brought to a high temperature, would be equally affected. Therefore, in comparing the strength of the weld with the original material, or considering the actual efficiency of the weld, corresponding heat treatment should be given to both the original and the welded piece. To get the best result, the heat treatment should be given after the weld is finished.

We have recently found that using a flux in steel welding will increase the strength of the weld at least 6 per cent. if conditions warrant. We assume that the poorer the conditions under which the work is done, the greater proportionate effect will the flux have in making a weld of any size, particularly in boiler work. It is always necessary to study the effect of shrinkage and the internal strain so produced, and particularly in repair work.

Three-License System

The writer strongly recommends that a system of examination be developed similar to that now in force in fire-insurance circles, and if the equipment is found satisfactory, it should be licensed to carry out work on vital parts in tension, and arrangements should be made that no equipment not so licensed should be allowed to do such work.

Not only should the torch be considered, but the whole equipment to be used. The manufacturers who have the best interest of the process at heart would gladly pay the expense of the investigation in connection with their individual equipments.

Owing to the low price at which welding equipments can now be purchased, nothing is to prevent an inexperienced operator from obtaining an equipment, and using it on boilers or other vital parts. Thus a disaster might occur that would detrimentally affect, if not prohibit, the use of the process on this class of work, thus also injuring those capable of giving satisfactory results. This is not likely to occur in states having inspection laws. The effect, however, in those states, should a disaster occur in the states not having inspection laws, would still be detrimental to the progress of the industry as such things are given snap judgment which does not consider the condition under which the work was carried out.

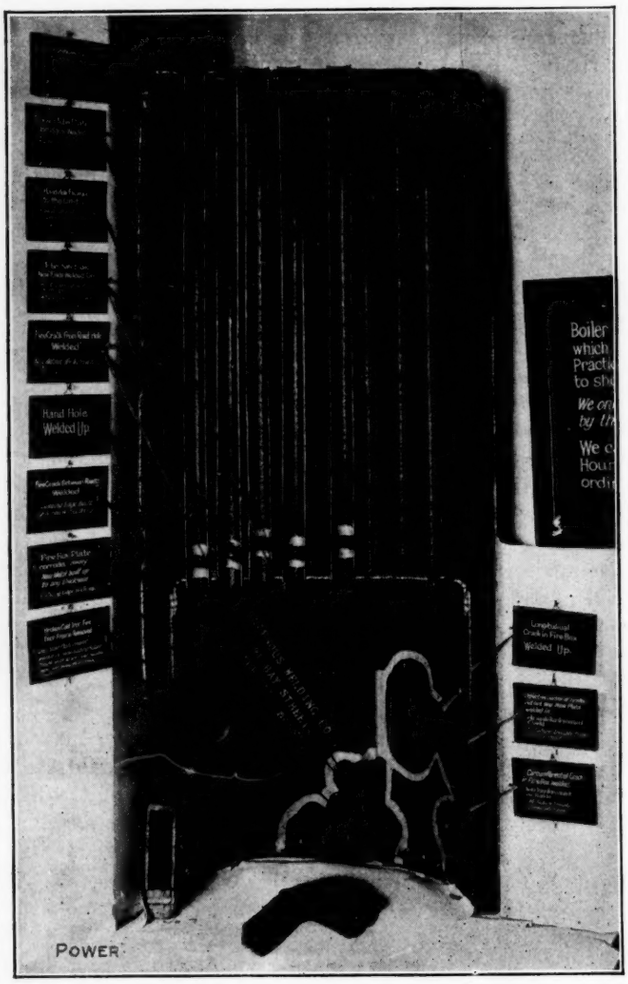
For the sake of the industry, therefore, no one should be allowed to weld on a boiler, irrespective of the type of work, throughout the whole of the United States, who has not passed an examination as to his ability to make a strong weld with a licensed equipment. It would seem that with these two licenses safety might result. Unfortunately, however, the operators, owing to the fact that a development of this sort generally attracts those who have not learned a trade, generally do not have any knowledge as to where and how and under what conditions their skill should be used.

Even though they can make a weld strong enough to pass the examination, they cannot judge as to the best materials to be used, the heat treatment, if any, necessary; they do not understand the structure of steel, and frequently could not decide which was a tension or a compression member, not having any knowledge of the structure of boilers. For success, such general knowledge is required, and, therefore, the concern using the licensed equipment and licensed operator should also be examined as to the technical ability available to determine such factors, and should be licensed accordingly.

These three licenses together would form what the writer has christened "The Three-License System," and it is his opinion that no work should be allowed to be done on boilers without the three licenses. All other restrictions should be removed, and if the concern having the Three-License System felt that it could weld such structures as steam boilers, using welds instead of rivets, without risking its license it should be allowed to do so. The license of the operator and the concern would check one another as neither of them would want to risk losing the license. Thus the industry would be placed on a sound basis which would result in a remarkable development in every direction.

Not only would the industry be benefited, but the

product would be improved and its cost reduced. The writer believes that 15 and possibly 25 per cent. of the trouble experienced with boilers is traceable to the riveted seams and conditions incidental to their design and manufacture.



BOILER WITH TYPICAL OXYACETYLENE WELDS, CUT THROUGH WITH OXYGEN JET

Cards read: "Circumferential and Radial Cracks in bend of upper tube plate flange"—"Cracked Tube Plate Bridges Welded"—"Hand Hole Enlarged to the Limit. Welded up and original sized hole cut with oxygen cutting torch"—"Tubes Safe Ended New Ends Welded On"—"Fire Crack from Rivet Hole Welded. Hole welded for reriveting"—"Handhole Welded Up"—"Fire Crack Between Rivets Welded. Landing edge built up to renew calking"—"Firebox Plate Corroded Away. New metal built up to any thickness. Calking edge built up"—"Broken Cast Iron Fire-Door Frame Removed, and steel plate frame welded in. "Longitudinal Crack in Firebox Welded Up"—"Defective Section of Firebox Cut Out and New Plate Welded In"—"Circumferential Crack in Firebox Welded."

The oxyacetylene process is being unfairly treated by those in position to make regulations controlling its use. In one state having boiler inspection, hand or forge welding is allowed on tension surfaces, limiting only the percentage of strength to be used in figuring the efficiency of the joint; whereas use of the oxyacetylene torch is entirely prohibited under any condition for welds in tension. Yet with hand or forge welding the only assurance of satisfactory results is the reputation of the man doing the work, who may not have been proved competent. His reputation may be based on his being a good all-around workman and having had few or none of his welds break, which may be because they were favorably located. Conditions such as the nature of the material used may influence the strength of the weld regardless of the skill of the workman. An inspector cannot determine whether the weld is good or not, even though he may have seen it made.

With the oxyacetylene process, however, satisfactory evidence may be obtained of the skill and reliability of the workmen, the possibility of success with the equipment having been proved. No uncertain variations of this are likely. There is, however, the additional advantage that an inspector could watch every movement of the operator and see that the weld was made completely through the piece, and that the metal was spread satisfactorily and could consequently determine the quality of the weld. The unjust discrimination against oxyacetylene welding in favor of forge welding, the strength of which cannot be judged without destructive tests, arises from forge welding being an old process.

Unfortunately, statements and reports have been made by men prominent in other fields regarding tests and other features of oxyacetylene welding which are generally taken as proved facts; these have seriously interfered with the development of the process.

A prominent European expert in that art recently declared that oxyacetylene welding should not be used in vital parts of containers until the strength of the weld can be determined without destroying it. The writer holds this to be practically an impossibility. That which makes such a thing desirable for the oxyacetylene weld, makes it equally so for other joints, which in years of use have not developed the means.

In the writer's opinion the strength of an oxyacetylene weld and the uniformity of results obtained are entirely a matter of satisfactory and uniform conditions.

New Jersey N. A. S. E. Visits

The first of the visits of the Visiting Committee of the New Jersey State Association of the N. A. S. E. was made to Jersey City No. 1 Association, Saturday evening, Dec. 20. The meeting was exceptionally large, there being about 200 present. State President Jenkinson presided.

Among the speakers was J. D. Taylor, Secretary-Treasurer of the Life and Accident Department, who told of the benefits and growth of the department. National President Coe, who followed, stated that the growth of the association was more than meeting expectations, and that he hoped to see 50 new associations organized this year. National Conductor J. J. Reddy, of Jersey City, told of the value the association had been to him and thanked those present for their support in electing him to office.

Charles H. Bromley, Chairman of the New Jersey State Educational Committee, stated that the line of demarcation between the mechanical and power-plant engineer was fast becoming less apparent. He outlined recent developments in plant practice and clearly showed that to meet the demands expected of him, the engineer must apply himself more closely to his art than was necessary in the days gone by. Sincere coöperation with the National and State Educational Committees was urged as vitally essential to the growth and prestige of the association.

John J. Calahan, Chairman of the Convention Committee that is arranging for the convention to be held in Jersey City next May, announced that the entire Elk's Hall building had been reserved and one of the biggest conventions and exhibits planned. He paid a high tribute to the convention committee of Newark No. 3 Association for its pioneer work and for the precedents it had established. "Bill" Cronnelly, one of the oldest members who has been active in engineering affairs since a time antedating the Civil war, thanked the young men for their work in making the association what it is.

F. A. La Pointe, of Hoboken, told of the proposals for lighting some of the Hudson County highways with current supplied by a new county-owned plant or by enlarging one of the two plants serving county institutions.

Among others who made interesting remarks were State Deputy Martin J. Hickey, E. W. Sears and George R. Starr.

A similar meeting was held by Newark No. 3 Association, Monday evening, Dec. 22. Refreshments and talent made the evenings enjoyable.

These visits will be continued throughout the season, the places and dates being as follows: Jan. 5, Hoboken; Jan. 10, Atlantic City; Jan. 20, Elizabeth; Feb. 2, Trenton; Feb. 12, Newark No. 8; Feb. 25, Paterson; Mar. 6, Plainfield; Mar. 20, Perth Amboy; Apr. 11, Passaic.

Verdict on Staten Island Boiler Explosion*

On December 16 was held the coroner's inquest into the cause of the boiler explosion which occurred at the Livingston plant of the Richmond Light & Ry. Co., on Oct. 21 last, and resulted in seven deaths. The lapse of nearly two months between the date of the explosion and that of the inquest is explained by the desire of the coroner to get at all the facts in the case. Unlike most investigations of its kind the inquest was conducted in an intelligent manner, the coroner and district attorney being represented in technical matters by C. G. Armstrong, consulting engineer for the city, and by Otto H. Klein, director of the Standard Testing Laboratory. The latter made a microscopic examination and test of the metal in the head and found an ultimate tensile strength of 55,000 lb. per sq.in.; also, the microphotoraphs failed to disclose any unusual condition in the structure of the metal. In view of testimony which developed during the hearing it is to be regretted that he did not subject the metal of the stays to similar tests.

It will be remembered that the boiler was of the vertical type and that failure occurred in the bottom head in almost a perfect circle at the "knuckle" or section where the curvature changes to form the flange.

Both Mr. Klein and Mr. Armstrong gave as their opinion that the failure was the result of breathing of the head which, being intensified at this section of greatest curvature, set up small annular cracks. Mr. Armstrong further testified that there was some pitting, but that the metal was not wasted away to any great extent. These opinions subsantiate those expressed in "Power" at the time.

Messrs. Nixon and Fitzgerald who inquired into the accident for the Public Service Commission believed the explosion to have been due to defective crowfeet stays between the head and lower tube-sheet; several of these having been welded. Mr. Fitzgerald testified that he had noted several welds in which the metal had been burnt and Mr. Nixon spoke of some of the crowfeet presenting a spongy appearance. Both spoke of the bad condition of the boiler plant in general.

While the opinions of Messrs. Armstrong and Klein, on the one hand, and Nixon and Fitzgerald, on the other, appear divergent, it is probable that both are correct. Mr. Armstrong and Mr. Klein are right in their contention that the head, if in good condition, should have supported the pressure at a reasonable factor of safety without staying. Substitution in the formula for convex heads as prescribed by the Board of Supervising Inspectors, U. S. Steamboat Inspection Service, also the Massachusetts Boiler Rules, will show this to be true. The stays in this boiler were primarily to support the flat tube-sheet although they may be considered to have afforded additional support to the head. What probably happened is this: The head itself became weakened at the point of failure through cracks set up by the breathing action described and possibly by some pitting or grooving until a stage was reached where it was dependent upon the stays for support. These being in a defective condition, gave way and the explosion resulted.

Most of the testimony pointed toward insufficient and incompetent operation. The superintendent had formerly been a lineman and two former chief enginers testified that one of their reasons for leaving was his interference with the operation of the steam end of the plant. The present chief engineer a few years ago was a motorman and his entire experience as an engineer had been gained at this plant. He had received his engineers' license about two years ago and had been in charge for about four months when the explosion occurred. Unfortunately at the insistence of the company's lawyer he was not permitted to answer some questions which might have thrown more light on the operation of the plant.

The man who was directly in charge of the repairs and inspection of the boilers had previously been a general handy man around the boiler room and received $3 a day for his services. He testified that he had internally examined the boiler on Sept. 27 and had looked over the stays, but had paid no particular attention to the head.

On the day of the accident the boiler had been blown down, filled with clean water and the fire started under it about 3 p.m. It had been up to pressure and cut in on the line only a few minutes when the explosion occurred. The man who cut in the boiler failed to put in appearance to testify, as did also the inspector from the police department; although it is doubtful if the latter would have thrown much light on the subject as he had tested the boiler eleven months previous to the explosion and this was not an internal inspection.

Mr. Shaw, chief inspector of the Travelers Insurance Co., testified that his company had previously held the boiler insurance, but owing to the general depreciation of the boiler plant and the attention it received, had refused to renew the policy when it expired last April. His company still held a liability policy with the power company, however. A letter was offered in evidence to show that the Maryland Casualty Co., which subsequently took over the risk, had made an external examination a short time prior to the accident, but there appears to have been no internal examination except the very superficial inspection by the power company itself.

In view of the foregoing evidence the jury arrived at a verdict which was in substance as follows:

That the explosion occurred while the boiler was under normal pressure as a result of a weakened condition of the lower head due to probable annular cracks and pitting at the section of failure and to defective stays.

While unable to find any one person criminally negligent to the extent that they could be successfully prosecuted, the jury in its verdict severely censured the management for inadequate maintenance and inspection of the boiler plant and for employing incompetent help without previous experience. It was further recommended that steps be taken to compel the management to install sufficient boiler capacity to permit boilers being taken out of service at regular intervals for inspection and repairs.

As an appendix to the verdict the jury recommended that the boiler inspection be taken out of the hands of the police department and placed in some department having the necessary experienced help to adequately inspect all boilers coming under its supervision.

*See "Power" for Oct. 4, 1913.

Montana Had No Boiler Explosions or Accidents in 1913

According to the recent annual report of Percy L. Brown, boiler inspector of the state of Montana, there was no boiler explosion or accident or injury to persons in charge of them in that state during the year ending Nov. 30.

During the year the department inspected 2260 boilers and condemned 21. Referring to the increased work, Mr. Brown remarks: The state is becoming more thickly settled and what was once a rolling prairie is now dotted with traction engines. They are now scattered from the northern to the southern boundaries of the state and from the far west to the prairies of the east, and are the most hazardous, arduous and expensive branch of the work of the department and will continue to be such until the many miles of prospective railroads are built."

Battleship "Vermont" Disabled at Sea

More than 400 miles east of Cape Henry the battleship "Vermont," on Dec. 17, crippled so badly as not to be able to proceed under her own power, was being towed toward Hampton Roads by her sistership, the "Delaware." Besides having her starboard main shaft broken and several of her compartments flooded on Dec. 11, the "Vermont" on Dec. 17 had some of the holding rivets on the port truss carried away. At the Brooklyn Navy Yard it was said that the ship must be without the use of her second engine.

The "Delaware" was reported as making about 3.7 knots. Previous to the last trouble aboard, the "Vermont" was making 8 knots under her own steam, with the "Delaware" and the colliers "Orion" and "Jason" close by.

The first accident occurred on Dec. 11, when at 3:45 o'clock the mainshaft snapped. Rear-Admiral Badger ordered a diver to go down and ascertain the extent of the injuries. He afterward sent a radiogram to the Navy Department, stating that the skin of the ship and the propeller strut gave no evidence of injury, and there was little cause for alarm.

From the scant description on which the mechanical experts at the Navy Department base their judgment, the belief is that the vessel's stern tube shaft must have been broken in the first place and that the auxiliary shaft has now

collapsed, to necessitate the towing of the vessel. The damage to the port truss, or frame, would account for the flooding of the compartments, and the bulkheads have probably been closed to confine the spread of the water in the hold. This report is taken from the columns of the daily press. The "Vermont" reached the Portsmouth (Va.) Navy Yard on Dec. 20.

OBITUARY

John B. Calvin, chief engineer, with the Grand Union Tea Co. for 22 years, died Dec. 18 at his home, 458 Van Buren St., Brooklyn, N. Y., from pneumonia, after a week's illness. He was born in Brooklyn 54 years ago, was a member of Ridgewood Lodge, F. and A. M.; Orient Chapter, R. A. M.; Damascus Commandery, K. T.; Kismet Temple, A. A. O. N. M. S., Welcome Council, R. A.; the National Association of Stationary Engineers and the Modern Science Club He leaves a widow, Gertrude Gilbert; four sons, Chester, Irving, James and John; two daughters, Adrienne and Gertrude, and a sister, Mrs. Robert Burns, of Manhattan. Funeral services were held at his late home Dec. 21, the Rev. Gurdon H. Eggleston, of the Greene Avenue Presbyterian Church, officiating. Mr. Calvin was a man of genial personality and had won a host of friends who will sincerely regret his sudden death.

SOCIETY NOTES

The regular monthly meeting of the New York Chapter, American Society of Heating and Ventilating Engineers, was held in the Engineering Societies Building, 29 West 39th St., New York, on Monday evening, December 15, with Vice-President J. I. Lyle in the chair. The topic of discussion for the evening was on "Atmospheric Conditions in Printing Establishments," and was presented by W. S. Timmis.

On Friday evening, Jan. 9, at 8:15, at the Engineering Societies Building, 29 West Thirty-ninth St., New York City, the American Society of Mechanical Engineers will hold a joint meeting with the American Institute of Electrical Engineers and the New York Section of the American Electrochemical Society. Dr. C. O. Mailloux will preside. The main topic will be "The Power Problem in the Electrolytic Deposition of Metals." The program: "The Limitations of the Problem," Lawrence Addicks, A. E. S.; "The Mechanical Side of the Problem," H. E. Longwell, A. S. M. E.; "The Electrical Side of the Problem," F. D. Newbury, A. I. E. E. The papers will be illustrated. Following the meeting the American Institute of Electrical Engineers will hold a smoker at its headquarters, to which the members of the Society are invited. An informal dinner (a la carte) will be served at 6:30 p.m.

PERSONALS

John Kirk resigned recently as chief engineer of the power house of the Portsmouth Electric Ry., Portsmouth, N. H., to accept the position of chief engineer of the "Cow Pasture" pumping station of the main drainage system of the city of Boston, at Dorchester, Mass. He had been the chief engineer since the opening of the power plant in 1899.

NEW PUBLICATIONS

SHOP SKETCHING. By Joseph W. Woolley and Roy B. Meredith. Published by the McGraw-Hill Book Co., New York City, 1913. Cloth, 6x9 in., 102 pages; 122 illustrations. Price, $1.

This book is an excellent treatise on elementary mechanical drawing. It is not intended to make draftsmen, but it gives all the necessary principles for the shopmen and apprentices who need a clear knowledge of mechanical drawing in their everyday work. These are given in the most direct manner by problems requiring the student to construct other views from given drawings.

The book consists of seven chapters, every one of which is a little compendium for the purpose it serves. It is interesting to note that the authors have confined themselves to the most necessary drawing instruments: Pad, pencil, scale or rule, eraser, and pencil-compass, the reason being that only these would be available "on the job."

Chapter 1 gives all the principles of mechanical drawing, including drawing from objects.

Chapter 2 deals with screws and screw fastenings, while some useful problems are left for the student to solve.

Chapters 3 and 4 take up all the possible sections and views of a mechanical drawing and also deal with the assembly and methods of expressing detail, in a clear and comprehensive manner without burdening the student with the rules of descriptive geometry. This is one of the most valuable chapters of the book, and it should enable the student to learn to visualize an object from a drawing.

Chapter 5 gives all the possible types of gears and calculations for laying them out, while Chapters 6 and 7 explain in much detail isometric and freehand drawings. The examples of isometric drawing on isometric and on plain paper are very instructive as the objects are taken from practice. The chapter on freehand sketching deserves a somewhat more detailed treatment as would be expected from the title of the book.

⁂

Situation for Inspector of Mechanical and Electrical Engineering—The United States Civil Service Commission announces an open competitive examination for inspector of mechanical and electrical engineering on Jan. 21, 22 and 23 to fill a vacancy in this position, at $2000 a year, in the Office of the Supervising Architect of the Treasury. Subjects: Practical questions in mechanical and electrical engineering, drawing and design, and training and experience. The duties consist of inspecting and testing the mechanical and electrical equipments entering into the modern Government or office building. Applicants should have had practical experience in the design, construction and inspection of heating and ventilating apparatus, plumbing, water-supply and drainage, conduit and wiring work, elevators, vacuum-cleaning systems, and electric generating plants. They must be citizens of the United States, 20 years old or over, and should at once apply for Form 1312 to the United States Civil Service Commission, Washington, D. C.

⁂

Situation for License Inspector—The Civil Service Commission of Chicago, Ill., will hold an examination, Dec. 30, for the position of license inspector, Class H, Grade II, salary $1080-$1440. Subjects of Examination: Special subject, penmanship, arithmetic, experience, report. Duties: To inspect steam plants; to see that licensed engineers and water tenders are in charge; to report to the department daily, in writing, on conditions found in the plants visited; to notify the department regarding engineers or water tenders who have not had their licenses properly transferred, or whose licenses are not uptodate; to act as a witness in court against violators reported by him, and to assist in office work when required.

⁂

Situation for Hoisting Engineer—The Civil Service Commission of Chicago, Ill., will hold an examination Jan. 8, for the position of hoisting engineer, Class Ea, Grade II. Subjects of examination: Special subject, experience, arithmetic, report. Further information can be had by addressing the secretary of the Commission, R. A. Widdowson, Room 610, City Hall.

⁂

Tests for Welded Joints—In our issue of Aug. 12 and 26 we announced that the Zentralbüro, für Acetylen und autogene Metallearbitung, at Nürnberg, had offered a prize for the best method of proving the integrity of a welded joint. On Nov. 11 the contributions submitted were examined by a committee presided over by Herr Geh. Regierungsrat, Prof. Dr., Ing. Dr. F. Wüst, of Aachen. It was decided that none of the contestants had offered a complete solution of the problem, but that of the 26 suggestions received, five had possibilities. These will be tried out and developed under Professor Schlesinger at the Klg. techpischen Hochschule, at Charlottenburg, and Professor Baumann, at the technischen Hochschule, at Stuttgart. It is hoped that one or the other of these proposed methods will offer a positive means of telling whether a welded joint is sound.

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Big Creek Development Supplies Emergency Service—The first power from the Big Creek Development in California was transmitted a distance of 241 miles to Los Angeles a few weeks ago, says the "Philadelphia Ledger," to supply emergency service arising through a temporary shutdown of part of the Redondo plant. This hydro-electric development is notable chiefly because it employs, in transmission, the highest voltage used to date, namely, 150,000 volts.